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ABSTRACT

The development of information technologies such as public access catalogs and online databases has greatly enhanced access to information. The lack of automation in the area of document delivery, however, has created a large disparity between the speed with which citations are found and the provision of primary documents. This imbalance can potentially be overcome through electronic document delivery, the use of electronic documents, and the media needed to transmit them. The purpose of this study is to provide librarians with a basic resource for technologies and standards that have potential for use in electronic document delivery and to provide examples of how they may be used to perform that task. The study includes: (1) an examination of current document delivery systems and the problems that reduce speed and efficiency; (2) an overview of state-of-the-art and emerging technologies, including electronic document conversion and generation, optical storage, data communication, workstation, and printing technologies; (3) examples of how technologies described in the previous section can be integrated; (4) examples of projects that attempt to automate previously non-automated stages of document delivery and to link them in a single system; and (5) a discussion of issues involved in electronic document delivery, including intellectual property rights, scholarly communication, the outlook for developing nations, and other concerns. (Contains 166 references.) (KRN)

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Electronic Document Delivery

Converging Standards and Technologies

Gary Cleveland

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1991

UDT Series on Data Communication Technologies and Standards
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Report # 2

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Converging Standards and Technologies

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1991

UDT Series on Data Communication Technologies and Standards for Libraries

Report #2

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About the series

Electronic Document Delivery: Converging Standards and Technologies is the second publication in *UDT Series on Data Communication Technologies and Standards for Libraries.* The purpose of this series, derived from the mandate of the IFLA UDT Core Programme, is to promote the electronic transfer of data, both between libraries and between libraries and their users. The current focus of the UDT programme is the standards and related technologies, as well as the policy issues, which provide the basis for electronic resource sharing among libraries. In addition to electronic document delivery, Series topics include: the use of research networks by libraries, organizational aspects of OSI for libraries, packet radio technology, and EDIFACT standards. Additional publications will be added to the Series in accordance with future UDT investigations.

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Gary Cleveland
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1. INTRODUCTION

The development of information technology has greatly enhanced access to information by automating its organization, storage, and retrieval. In contemporary libraries, technologies, such as public access catalogues and online databases, enable users to find information with an efficiency and speed far surpassing manual methods. Yet, despite increases in the scope of materials available and the ease with which references are found, users often experience long delays in receiving the actual document to which citations refer. This situation stems from the fact that:

- many pressures have forced libraries to shift from the *acquisition* of materials for local collections to providing *access* to those located at remote institutions, such that larger and larger percentages of documents must be requested and delivered from non-local sources
- information technology has been applied primarily to the retrieval of bibliographic information, rather than to the process of delivering primary documents to end-users.

The lack of automation in the area of document delivery has created a large disparity between bibliographic access and document supply—the speed with which citations are found is not matched by the provision of the primary document. Although certain aspects of the document delivery process have been automated, such as the electronic exchange of requests, other aspects, such as the final transfer of documents, remain largely dependent on traditional manual methods. This disparity, furthermore, threatens to become even more acute as a result of the quantum leap in bibliographic access provided by recent developments of end-user searching of locally mounted citation databases, CD-ROMs, and network-accessible library catalogues.

The imbalance between access and supply can potentially be overcome through *electronic document delivery*—the use of electronic forms of documents and transmission media to automate the entire document delivery process, from the initial selection of a relevant citation, to the final delivery of the document. The creation of electronic document delivery systems can bring the incompletely automated process of document delivery into one integrated system, allowing users, whether they are ILL staff or researchers, to select, request, and obtain primary documents from a variety of sources directly from their workstations.

Information networks

Providing direct access to primary documents will be a crucial function of the electronic libraries, sometimes referred to as *virtual libraries* (CNI, 1990), envisioned in the coming decades for the computer networks that link academic and research institutions. There is a strong momentum within the international academic community to create information networks capable of providing access to vast electronic information resources. Major initiatives include the U.S. National Research and Education Network (NREN) which calls for the upgrading of the *Internet*—a TCP/IP-based network that interconnects a large number of regional networks throughout the United States and on other continents—into a high-speed, high-capacity research network by the mid-1990's. This network will connect more than 1000 colleges, universities, and research organizations, allowing enhanced information access and exchange.

The first step toward the development of information networks is to provide desk-top access to widely dispersed bibliographic information resources (Lynch, 1990). Many information resources—OPACs, CD-ROM databases, and locally mounted citation databases—are becoming available through campus-wide, regional, and national research networks (e.g. the *Internet* in the U.S., JANET in the United Kingdom, and IXI in Europe). Using these networks, researchers can access bibliographic databases located across a campus, across a country, or on another continent directly from their computers.

The next step will be to make the documents themselves available through the networks (Lynch, 1990). To accomplish this step, the development of electronic document delivery (EDD) software "applications" will be required. An application is a set of tasks that satisfy some information processing requirement for a human or machine end-user. An EDD software application would, for example, incorporate a variety of mechanisms that would provide the ability to search disparate remote databases for citations, locate primary electronic documents in appropriate forms, pay any applicable surcharges for copyright and other business arrangements, and transmit documents to the requesting workstation.

Converging technologies

There are a number of international standards and technologies that are becoming available to create such EDD software applications. The phrase, *convergent technologies*, refers to the fact that developments in a number of separate fields have been coming together to make such systems possible. These developments include:

- ***electronic document conversion and generation technologies***, such as scanning and optical character recognition (OCR) software, standards for document representation, such as Office Document Architecture (ODA) and Standard Generalized Markup Language (SGML), and trends toward computer-based authoring and typesetting

- ***storage technologies***, such as CD-ROM, Write Once Read Many (WORM), and Erasable-optical discs, and the falling cost of mass storage

- ***workstation technologies***, such as high-end RISC-based systems, and X Windows-based graphical user interfaces, and the growing base of installed machines

- ***communications technologies***, including standards for high-speed LANs, such as Fibre Distributed Data Interface (FDDI), enhanced research networks, and Integrated Services Digital Network (ISDN)
- ***hardcopy production*** such as Group IV facsimile machines laser printers and high-end document production equipment.

Scope and terminology

The terminology used in the area of document provision is extremely problematic. Many terms are used to denote the wide range of services that have evolved to provide documents to end-users, including *interlibrary loan* (or *interlending*), *document supply* and *document delivery*. Unfortunately, these terms are often used interchangeably in the literature leading to some confusion about the exact domain of each. For example, originators of requests can be end-users themselves, or libraries as intermediaries; document types can be originals or copies; and sources of documents can be one, or any, of libraries, publishers, document supply centres, or commercial document suppliers (cf. Boss and McQueen, 1983; Braid, 1989; Currie and Olsen, 1985; Miller and Tegler, 1988; Plassard and Line, 1988).

The term most commonly used in current literature is *document delivery* (Braid, 1989; Currie and Olsen, 1985), though it, too, has been shown to have definitional problems (Ghikas, 1985). For example, definitions of document delivery can be very narrow, referring simply to the *transfer* of a document from a supplier to a requesting library (Boss and McQueen, 1983) or directly to an end-user (Ghikas, 1985). They can also can be very broad, referring to the *set of processes* associated with the delivery of a specific document, thus including selection, requesting and final transfer (Plassard and Line, 1988).

In the present study, *document delivery* is used in its widest sense, referring to all aspects of the process of providing documents to end-users. Specifically, it is defined as *the provision of documents as surrogates (e.g., photocopies, microforms, digital images) that are retained by the user.* This definition is meant to apply regardless of whether the request is made directly by the user or is intermediated by a library, or where or what type of source provides the document. Thus, document delivery may include, for example, requests mediated by a library for a photocopy of a document held by another library or by a commercial document supplier, or it may include requests made directly to a commercial document supplier by an end-user. Furthermore, document delivery in this study is considered to involve the wide range of activities that precede the final transfer of a document, including the initial selection of a relevant citation, the location of a source, the submission a request, and the retrieval the document.

One major assumption that has been made while developing the EDD application outlined in this study is that the Transmission Control Protocol/Internet Protocol (TCP/IP) will likely continue to be a major force in networking for some time, and that implementations of OSI application protocols will become increasingly available on networks: thus, the two protocol suites will likely have to coexist in some fashion (see Section 3.3.4.3). In some cases, applications will likely need to support protocols from both suites (Lynch 1991a). This study, however, focuses primarily on the application of OSI protocols electronic document delivery.

Goals of the study

The purpose of the present study is to provide librarians with a basic resource for technologies and standards that have potential for use in electronic document delivery, and to provide examples of how they may be used to perform this task. To this end, the study first examines the current document delivery environment within which documents are provided to end-users, outlining the problems that affect the speed and efficiency of the document delivery process. It then describes the set of converging technologies and international standards that are available to create electronic document delivery (EDD) systems.

Based on this discussion, the study goes on to provide examples of configurations sufficient to support electronic document delivery. The systems include both those that are probable for the present and for a transition phase (1-5 years), as well those that are possible in the longer-term (5 years or more). This latter category includes integrated EDD software applications that will provide library staff and/or end-users with direct access to primary documents. It also discusses some major experiments in electronic document delivery, and touches upon related issues.

Although the study presents a model for an integrated EDD application, it is impossible to predict the exact configuration that may appear at the focal point of the converging technologies; the difficulties of actual implementation will necessarily change any abstract model for electronic document delivery. Such unpredictability illustrates the difference between Richard West's conception of *research* and *innovation*, as articulated by Clifford Lynch (1991b). Whereas research involves the process of "investigation, study and experimentation," innovation involves the activity of "applying advanced technology within an organizational or national setting to change the way the system operates" (p. 4). Because innovation must address "the rich, complex set of interactions that will occur between new technology and existing practices, systems, and organizations" the outcome of a project can be significantly different than those expected (Lynch, 1991b:5).

Using this dichotomy, the model for electronic document delivery presented in this paper falls most appropriately within the domain of research. Although it may be significantly altered by innovation, it nonetheless provides the basis for study of the interrelationship among various standards and technologies, and illustrates the manner in which they may be used in conjunction to perform electronic document delivery.

Organization of the study

1. ***Introduction***

2. ***Current patterns in document delivery*** To understand the need to make systems supporting document delivery more efficient through electronic means, it is important to examine current patterns in document delivery, and the problems that can reduce its overall efficiency. This

chapter outlines the impetus for document delivery, as well as its processes, participants, and problems.

3. ***Convergent technologies: Overview*** This chapter provides an overview of the state-of-the-art and emerging technologies that are available as "building blocks" for the construction of an electronic document delivery system.

4. ***Electronic Document Delivery Applications*** While Chapter 3 describes each convergent technology in a generally independent fashion, Chapter 4 describes how the technologies can fit together into a whole. Several example configurations that automate the functions contained within the document delivery process are used to illustrate the manner in which the technologies can be integrated.

5. ***Selected Document Delivery Projects*** While few working systems currently exist that integrate all the functions within the document delivery process, there have been some projects that have attempted to automate previously non-automated stages of the document delivery process, and link one or more of these stages within a single system. This section describes these projects as examples of development activities.

6. ***Issues In Electronic Document Delivery*** The shift from paper-based information systems to integrated electronic document delivery systems will have a strong impact upon established patterns and processes associated with information production, access, and distribution. This chapter discusses some important issues in this area.

7. ***Conclusion***

2. CURRENT PATTERNS IN DOCUMENT DELIVERY

To understand the need to make document delivery more efficient through electronic means, it is useful to examine current patterns in document delivery, and the obstacles compromising its overall efficiency. To this end, the present chapter provides some background material, first outlining the initial impetus for document delivery—the need to share resources among libraries—and the growth of this form of resource sharing. Second, it examines the varied setting within which documents are procured for end-users (referred to in this study as the *document delivery environment*). The general process of document delivery, its major participants, and inherent obstacles are examined. Finally, the present chapter briefly introduces the international standards and technologies available to create electronic document delivery platforms and software applications that are covered in detail in Chapter 3.

2.1 The impetus for document delivery

Since the 1940's, few libraries have been able to collect individually the full range and quantity of materials demanded by their users. They have, by necessity, become heavily dependent upon external sources of materials to supplement the materials held in their local collections (Fjällbrant, 1988). It is currently estimated that "no library can afford to acquire even half" of all published material (Graves and Wulff, 1990:53). An average size academic library, for example, may subscribe to 3000-10,000 journal titles, representing at most only 4% of titles available for acquisitions, based on total active titles in the Faxon database in 1989 (from Graves and Wulff, 1990). The reasons behind the falling proportion of acquired versus available materials are manifold:

- ***the proliferation of published information***. In the last half century, there has been an exponential growth in the amount of information published annually. More information has been produced in the last 30 years, for example, than in the last 5000 years (Wurman, 1989). A large part of this growth in information has been in the area of science and technology, collected largely in academic journals (Line, 1989b). There are currently over 1,000,000 journal articles published per year in the sciences alone (Cohen, 1990). At current rates of increase, the number of published articles is expected to double in 15 to 17 years (Petersen, 1989).

- ***economic constraints***. Funds available for acquisitions, already representing the largest portion of library budgets, have not kept pace with the increase in published information.

Libraries cannot afford to acquire, catalogue, and house all the materials that may be required by their patrons. As one author succinctly states, "the exponential increase in the amount of published information has not been paralleled by an exponential increase in library acquisition budgets" (Fjällbrant, 1988:16). Factors putting further strain on library budgets are inflation, poor economic times, and currency fluctuations (Cargill and Graves, 1990).

- *rising cost of serials.* Along with stagnant budgets, the purchasing power of libraries has been eroded by large increases in the price of academic journals. For example, Faxon estimated that the average price of serials purchased by college and university libraries rose by 13.7 percent in 1987, 12 percent in 1988 (Akie, 1988), and by seven percent in 1989 (Young, 1989). These figures are moderate compared with those estimated by individual university libraries such as the University of Michigan, which showed a price increase of 24 percent for materials purchased from three publishers (Elsevier, Pergamon, and Springer) (Dougherty and Johnson, 1988).

The above factors have not only prevented libraries from collecting the increasing amount of available information, but have actually forced many libraries to reduce the number of serials titles they already hold. In 1988, for example, a survey produced by the Canadian Association of Research Libraries (CARL) revealed that between 1978 and 1988, a Canadian sample of research libraries canceled a total of 40,406 subscriptions with more cancellations planned for the future (Lee, 1989).

2.1.1 The growth of document delivery

Despite rising costs, shrinking budgets, and an information explosion, the library's role remains to mediate access to recorded information required by their users, even if each library is unable individually to acquire and preserve it in its entirety. To continue to provide users with access to as wide an array of information as possible, libraries have had to shift away from the acquisition of materials for local collections to cooperating with other libraries to provide access to them (Graves and Wulff, 1990). Such cooperative activities are now highly developed, encompassing a variety of programmes including coordinated acquisitions agreements, reciprocal borrowing privileges, union catalogues, mutual purchase notification, catalogue production, and joint purchases (St. Clair, Butcher and Scott, 1990).

The primary mechanism for sharing materials is what has traditionally been known as interlibrary loan, involving the mutual lending and borrowing of materials among libraries. Beginning in the previous century, this activity has since experienced many advances that have included the formal codification of ILL procedures, the establishment of reciprocal borrowing privileges between libraries, the standardization of loan forms (Kilpatrick, 1990), and the development of ILL telecommunications networks for the exchange of requests (Ra, 1990).

The use of interlibrary loan has grown phenomenally in the last 40 years. While no precise figures of the rate of increase of ILL requests exist, one source estimates that, worldwide, it has grown by at least a factor of four since the 1950's (Line, 1989a). Other figures suggest even higher rates of increase. A study of interlibrary loan rates among Association of Research Libraries (ARL) members showed that from 1977 to 1987 total inbound requests for materials increased by 33.9 percent. Outgoing requests increased even more dramatically, a total of 79.6 percent for the same period. An interesting finding is that the total rate of increase for ILL was significantly higher than that for the size of collections. This disparity suggests that user demands for information exceeded the ability of local collections to satisfy them (Budd, 1990).

Overall, the volume of material transactions currently numbers well into the millions worldwide. At the end of the 1980's in the United Kingdom, for example, libraries recorded approximately three million interlending transactions (Line, 1989b). In North America, estimates from annual transactions processed by ILL messaging systems of major utilities (OCLC, RLIN, WLN, and DOCLINE) and regional library networks (ILLINET) approaches 20 million annually (Jackson, 1990a).

While the major underlying factor in the steady increase of interlending may be the growing inability of libraries to be self-sufficient, other factors have also contributed to this accelerated growth:

- ***increased user access to bibliographic information*** Traditionally, access to bibliographic information through card catalogues and online public-access catalogues has been restricted primarily to items actually housed within the library. Access to items beyond the local collection, by contrast, has been limited, provided mainly through print or microform union catalogues that are clumsy to use and are quickly outdated (Cornish, 1989). The arrival of new technologies, such as online searching, CD-ROMs, and locally mounted journal index databases, has greatly enhanced access to materials beyond the local collection (Cohen, 1990). This has swelled the rates at which materials are requested from outside institutions (Gyeszly and Allen, 1991). As an example, interlibrary loan rates increased substantially at the University of California after creation of the MELVYL MEDLINE system that provided access to the MEDLINE bibliographic database through the public access catalogue (Lynch and Berger, 1990).

- ***improved requesting procedures*** ILL rates have also increased because of improved requesting procedures for ILL transactions. Interlibrary loan processes have become increasingly automated resulting in significant improvements over manual methods (Turner, 1990). This automation has focused largely upon facilitating the location, verification, and exchange of ILL messages between lending institutions (Boucher, 1987). Examples include the development of ILL subsystems operated by bibliographic utilities, such as OCLC, RLIN, and WLN in the U.S. and the use of public electronic mail systems, such as ON-TYME II and ALANET for transactions.

One of the most important factors that has transformed interlibrary loan and many of its processes is the arrival of rapid reprographic techniques (Kennedy, 1987). Photocopy machines allow copies of documents, as well as specified pages of documents, to be "lent" to users permanently.

Copies can be supplied much more cheaply, efficiently, and there is no risk of lost or damaged materials to the lending library (Braid, 1989). More importantly, individual articles from academic journals, previously listed among the categories of materials that libraries could not request (Kilpatrick, 1990), can be supplied to remote users. The ability to deliver a primary document to a user in the form of a photocopy expanded the traditional domain of interlibrary loan from simple book lending to include document delivery services (Kennedy, 1987).

2.2 The current document delivery environment

Currently, document delivery is not restricted solely to interlibrary loan, or to libraries. As one writer states, "interlibrary loan is no longer just library to library. It is also library to commercial source, or commercial source to library" (Jackson, 1990b:99). It also may be commercial source directly to the user (Conhaim, 1991). Traditional sources of documents and methods for procuring them have multiplied such that there are many ways to obtain requested materials for users (Cornish, 1989). For example, documents may take the form of photocopies or original, requested by telephone, email or ILL subsystem, procured from libraries, document supply centres, or commercial suppliers, and sent by ground mail, courier, or fax.

Examined as a whole, the variety of sources and methods of obtaining materials may be considered to constitute a *document delivery environment*—the setting within which information is provided to end-users. When viewed in this more abstract manner, several general components or entities, as well as a number of processes, can be identified.

Specifically, the components include:

- ***requestors*** who originate the request
- ***various document types*** that are the focus of the transaction
- ***document sources*** from which the documents are procured.

The process of document delivery can been seen to be composed of several general functions or processes, regardless of the specific types of documents, requestors, and document sources involved:

- ***document selection***, involving the identification of a document that meets a user's information need
- ***request management***, including verification of a citation, location of a document source(s), submission of the request to the document source, request tracking, as well as establishing copyright compliance and billing.

- ***document retrieval***, involving the storage media of the original documents that affect the form of retrieval and other processes at the document source

- ***document transfer***, involving the delivery of a document from a document source to a requestor

The following sections examine the above components and functions in greater detail, outlining current practices, and identifying those areas that interrupt the process and reduce the efficiency and response time of document delivery.

2.2.1 Requestors

There are two main requestors in the document delivery environment from which requests can originate:

- ***library end-users*** The principal requestor in the document delivery environment is the user of public, academic, special, or private sector libraries who has a bibliographic record for which he/she needs the primary document; it is from the end-user that all requests originate. Although some libraries have developed provisions to allow end-users to submit requests directly (cf. Potter, 1986), the request in most cases is negotiated by the user's local library. This is changing, however, with individuals increasingly becoming direct users of commercial document delivery services (Conhaim, 1991)

- ***libraries*** The library, specifically, the interlibrary loan department or campus document delivery service, acts as mediator on behalf of an end-user. This is because: 1) users often regard the library as the "first port of call" when seeking a document; 2) ILL staff have greater expertise in procuring documents; and 3) ILL departments have been empowered to authorize payments for documents (Martyn and Singleton, 1985)

2.2.2 Document types

The types of documents that exist in a traditional document delivery environment include all those that are acquired, stored, and supplied by a library for use by its patrons (Software Kinetics, 1990). This includes a wide variety of document types:

- ***traditional printed matter***, such as monographs, serials (journals and their component articles), newspapers, reference works, government documents, doctoral dissertations and master's theses, and printed music

- ***rare books and manuscripts***

- ***cartographic material***

- ***audio-visual material***, such as published audio and video recordings (LPs, Compact discs, magnetic tape), radio and television archives, and film
- ***pictorial documents***, including graphic art and photographs
- ***statistical and other tabular material***
- ***databases, software, multimedia objects***

Some of these materials would not be the focus of ILL transactions because they are non-circulating. For example, whole academic journals, rare books, films, videotapes, phonograph records and compact discs are typically non-circulating items (Kilpatrick, 1990; Boss and McQueen, 1983). However, electronic imaging techniques, discussed in Section 3.1.1, will undoubtedly change policies for access to traditional non-circulating items by allowing electronic images to be circulated in their place (Lynch, 1991a).

Document surrogates

Document delivery, according to the definition used in this paper, deals with *surrogates* of documents that users can retain for their collections. Document surrogates are substitutes, such as microforms, photographs, photocopies, that stand in the place of an original physical document. Currently, the most prevalent is the photocopy which allows the delivery of individual journal articles and other types of documents inexpensively and efficiently. There is also a trend toward increasing use of this type of document surrogate. By 1980, for example, the proportion of documents supplied as photocopies was 47.1 percent for academic libraries, (Boss and McQueen, 1983). Four years later, Waldhart (1984), estimated that the proportion of photocopies supplied by research libraries had risen to 60 percent per year, an increase of 5.5 percent.

Document surrogates have two characteristics that makes them appealing in document delivery systems: 1) they allow the wide distribution of information contained in documents, or parts of documents, that may otherwise be less available; and 2) they facilitate the sharing of materials by allowing the information in one original to be used simultaneously by many users in different locations. While these characteristics have raised serious questions of copyright (see Section 6.1), they are precisely those that make electronic documents useful in electronic document delivery systems; whether an electronic document is a digital image of the traditional materials outlined above, or a document originally authored and retained in electronic form, they can be used simultaneously in a network system by a large and widely dispersed group of individuals.

2.2.3 Document sources

The document sources available to libraries within the document delivery environment have become more diverse over the last twenty years (Cornish, 1989). The traditional source for documents for interlibrary loan was other libraries, but with the growth of technology for reproduction and bibliographic access, other sources have proliferated. Major document sources currently include *libraries, document supply centres, commercial document supply services* and *publishers*:

- ***libraries*** The predominant source of primary documents is still libraries, particularly in the U.S. and Continental Europe (Willemsen, 1988). In the U.S., a resistance to a loss of autonomy, and the development of bibliographic, regional, and local library networks facilitated this decentralized approach (Dougherty, 1990). These networks currently support coordinated acquisition policies, reciprocal borrowing privileges, and document delivery, as well as many other resource sharing activities (Shaughnessy, 1987). The development of OCLC, in particular, has supported this decentralized approach by increasing access to holdings information of widespread libraries (Boucher, 1987; Wheelhouse, 1988). Resource sharing among libraries is facilitated by tools such as union catalogues and union lists of serials.

- ***document supply centres*** Another major source of documents is document supply centres—centralized non-profit sources of documents whose service communities are national, and often international, in scope. The premier example is the British Library's Document Supply Centre (BLDSC) at Boston Spa. The BLDSC is responsible for collecting publications and making them available both within the U.K. and world-wide, and serves as the major source for documents in the U.K. Fully 90 per cent of British ILL requests, for example, are estimated to be requested from the BLDSC (Stone, 1990). Although the U.S. uses primarily a decentralized approach, the Center for Research Libraries (CRL) was designed to act as a national lending library: the future of this document centre is, however, uncertain (Wheelhouse, 1988).

  In France, a role similar to the BLDSC has been played by the *Centre de Documentation Scientifique et Technique* (CDST) (Kent, Merry, Russon, 1987). The CDST has been the largest supplier of documents in France. The CDST and CDSH (a similar centre for documentation in the humanities, social science, and economics) have been recently combined to form *Institut de l'Information Scientifique et Technique* (INIST) located in Nancy (Lupovici, 1990).

- ***commercial document supply services*** The third major source of documents available in the document delivery environment is commercial document supply services that specialize in finding and supplying documents on a for-profit basis. Appearing during the 1970's, the number of these services has grown from 35 in that year to 269 in 1987 (Finnigan, 1988). They can be divided roughly into two basic types: those who supply documents from their own sources, and those who procure documents using a variety of sources (often referred to as *information brokers*) (Kennedy, 1987). Unlike libraries, they generally do not engage in on-site borrowing and primarily supply photocopies rather than original material. Although most commercial document supply services will supply a wide range of materials, some specialize in delivering particular types of documents (e.g., standards, patents) or documents on particular subjects (e.g., business, engineering).

Examples of major services include the Chemical Abstracts Service Document Delivery Service (CASDDS) managed by the American Chemical Society's Chemical Abstracts Services which supplies photocopies of articles indexed in its print and online chemical abstract database (Kennedy, 1987), and University Microform International, which ranked as the largest supplier of documents on the OCLC ILL Subsystem from 1984-1989 (Jackson, 1990b). Other examples are Information on Demand (IOD) one of the oldest commercial information brokers (now owned by Pergamon), and the Institute for Scientific Information (ISI) (see Erwin, Ward, and Emerson, 1987, for a list of other commercial document sources).

Although libraries have not been the traditional clientele of these services, they have increasingly begun to use them as an alternative to ownership of infrequently used materials (Ardis and Cronesis, 1987). By the end of the 1980's, commercial document supply centres have become "an accepted alternative for the provision of needed documents" (Jackson, 1990b:99). In addition, individual users are increasingly becoming direct users of commercial document delivery services (Conhaim, 1991)

- ***publishers*** Publishers can also act, to some extent, as document suppliers through the sale of reprint and article copies. One early study indicated that there was an increasing tend in this activity with the number of article copies sold by U.S. publishers rising from a total of 16.18 million in 1976 to 34.37 million in 1980 (McDonald and Bush, 1982).

2.2.4 Functions

A number of specific functions can be identified within the overall document delivery process. These functions are those that must be performed in order to obtain a document for a user, without regard for the specific types of documents, requesting entities, or document sources involved. They fall broadly into the categories of *document selection*, *request management*, *document retrieval*, and *document transfer*. Although many of the functions within these domains have been automated to some degree, problems remain that reduce the efficiency of the overall document delivery process. Such obstacles include, for example, manual procedures, redundant of clerical work, and conflicting communications channels.

2.2.4.1 Document selection

Document selection involves the activities necessary to determine what document is required to meet a user's particular information or research need. Selection is usually accomplished by searching through a number of bibliographic references on a given topic and selecting the most promising citations. Although finding bibliographic references is not generally considered to be part of the document delivery process, it is the first stage in the overall process of obtaining information and is, as such, a precondition of document delivery.

Current methods Finding bibliographic references is currently the most highly automated function within the document delivery process. Most manual, paper-based methods of finding citations, in fact, have long since given way to automated information retrieval—the process of searching an electronic database for relevant materials on any given topic. Since the development of early online information systems and online public-access catalogues (OPACs) in the 1970's, systems supporting information retrieval have proliferated (Arms, 1989). In the current environment, end-users have access to a wide range of bibliographic resources: OPACs, commercial online systems, CD-ROM databases, and locally mounted citation databases. Increasingly in the academic community, such resources are becoming available through campus-wide, regional, and international networks that enable users to access them from their computers. Users thus can access databases located across a campus, across a country, or on another continent.

An important characteristic of contemporary information retrieval systems is that they have expanded bibliographic access to a wider variety of materials, regardless of whether these materials are available in local collections (Cohen, 1990). Prior to widespread use of bibliographic databases, users were restricted to searching through OPACs that contained primarily monographic material and items actually housed within the library. Access to other types of materials, such as journal articles and non-local materials, was restricted to clumsy and quickly outdated print or microform union catalogues (Cornish, 1989). The advent of online searching, CD-ROMs, locally mounted citation databases, and network-accessible catalogues has given widespread and direct access to these materials, greatly expanding the range and quantity of bibliographic resources from which to select documents.

Current obstacles Despite the benefits that automated information retrieval has meant for information access, obstacles remain that limit the efficiency of these systems. The first major problem is that this wide range of information resources is not available through one channel in a consistent manner (Ra, 1990). Instead, engaging in an exhaustive search on a topic often means repeating a search on a variety of systems, each typically involving a different search interface and a separate communications channel. It is also currently impossible to combine result sets from these searches in order to eliminate redundant citations. Furthermore, it is presently difficult to discover the locations of information resources that are available through computer networks (Lynch and Preston, 1990).

A problem more germane to the present discussion of document delivery is that current information retrieval systems are not connected to systems used at other stages in the document delivery process. The speedy manner in which a user may have found a reference to a document is suddenly halted before the primary document is obtained, most abruptly if the document is not available locally. To get a document, users must go physically to an ILL department, write out an ILL request, and wait many days or weeks to obtain the needed material. This lack of linkage between information retrieval systems and other, often non-automated, systems for retrieving and delivering documents, contributes to the discontinuity between the access and supply of documents. Some institutions, however, have begun to provide linkages from OPACs to campus document delivery centres that provide delivery services through campus mail (Lynch, 1991a).

2.2.4.2 Request management

Once a user has selected and issued a request for a document, the process that has been traditionally associated with document delivery begins. This is set of functions that revolve around the negotiation between a requestor and document source for a document surrogate, termed here as *request management.* These functions include activities such as verification of the citation, compliance with copyright restrictions, and location of a potential document source or sources. The above functions are followed by request submission, request tracking, as well as a number of other possible transactions. While the request management portion of the document delivery process has also been automated to a degree, some problems do remain. These problems primarily involve discontinuities between the various systems designed to perform request management.

Verification, compliance with copyright, and location
Before an actual request can be submitted, the requesting library acting as intermediary must first verify the accuracy of the citation and take steps to ensure copyright compliance (Kilpatrick, 1990). It is the responsibility of the requestor to verify that the reference supplied by the user is correct. At the same time, potential document sources for the document can be identified. This is an important step in the process because the proper choice of document source can be made based on factors such as source location, lending policies, charging policies, and restrictions on use, and thus may considerably speed up the delivery of a document (Boucher, 1984). Some systems, such as the University of California, have a link between the OPAC and a union list of serials thereby by-passing citation verification as well as streamlining identification of a location (Lynch 1991a).

With photocopies of journal articles or other materials, a further step performed by libraries involves checking a file of previous photocopy requests. Each request is checked against this file in order to ensure compliance with copyright law or guidelines such as those issued by National Commission on New Technological Uses of Copyrighted Works (CONTU) in the U.S. (Kilpatrick, 1990). These activities, designed to ensure adherence to library guidelines, are not needed if the request is submitted by a user directly to a commercial document supplier who generally establish their own agreements with copyright holders.

Current Methods Traditionally, the way to verify citations and discover the location of a particular item was to use a paper-based union catalogue or a union list of serials (Cornish, 1989). These tools, though still in use, quickly become out of date. With the advent of machine-readable bibliographic databases and network technology, access to holdings information became more efficient, accurate, and up-to-date. These databases also provided access to a larger number of materials by combining the holdings of many libraries, as well as including a variety of languages and material types.

In some countries, these databases exist as national union catalogues accessed through centralized networks. In the Netherlands, for example, the Pica database acts as a centralized bibliographic resource for Dutch libraries (Buitelaar, 1990). A similar approach is taken in Finland with the

BIBSYS database which acts as a centralized database to support subsystems from acquisitions to circulation control, with support of ILL under development (Gunderson, 1991).

In Britain, holdings information is available largely through the union catalogues of regional library networks. Examples include Blaise/Line, BLCMP, and SWALCAP. While attempts have been made to create national union catalogues, such as the United Kingdom Library Database System (UKLDS) project, they have been largely unsuccessful (Jones, 1990). An exception is the more recent, though smaller in scope, Consortium of University Research Libraries (CURL) database consisting of the collective bibliographic records of CURL libraries (Heaney, 1989).

In the U.S. and Canada, holdings information is obtained through the cooperative databases of bibliographic utilities, such as OCLC (Online Computer Library Center), Research Libraries Group (RLG), and Western Library Network (WLN), Utlas, Inc. and Dobis (National Library of Canada). These databases serve as *de facto* national bibliographies and have largely replaced paper-based national union catalogues as the major source of holdings information (Ra, 1990). The union catalogue of OCLC alone, for example, contains bibliographic and holdings information for nineteen million items (McGill and Racine, 1990).

Request submission and tracking

Once a citation has been verified and possible locations found, messages are exchanged between the requestor and the document sources in an effort to secure a copy of the item. This process involves various transactions including submission of the request to a document source and subsequent tracking of the status of the request. This particular set of functions for ILL (Turner, 1990), and commercial sources (Finnigan, 1988) has been highly automated with significant improvements in service over manual methods .

Current methods While letters, paper forms, telephone and fax are still used to request documents, manual methods of request submission and tracking have been supplanted by a variety of electronic methods. The earliest of these were teletype-based (TWX) systems, later replaced by ILL subsystems operated by bibliographic utilities, such as OCLC, RLIN, and WLN in the U.S. (Jackson, 1990a). ILL sub-systems allow all aspects of request management, from item location to request submission and tracking, to be done automatically without the need for rekeying. Within the OCLC subsystem, for example, a library can submit a request to up to five potential document sources. The Subsystem then automatically forwards the request successively to each library until a consenting library is found. The status of the request is maintained for the duration of the transaction in an online message file that the entities involved in the transaction may access (Boucher, 1987).

Other methods of request submission and tracking include the use of public electronic mail systems, such as ON-TYME II, ALANET, and networks specific to a geographic location, such as ILLINET and DOCLINE (Turner, 1990). In Britain, most requests are handled by the British Library's Document Supply Centre (BLDSC) (Stone, 1990) through ARTTel, an online service for requesting loans or photocopies from the BLDSC (Buxton, 1988). An example of a commercial document supplier's online system is Faxon's ICORE.

Current obstacles In the current document delivery environment, there is a variety of incompatible messaging software to create messages and a variety of telecommunications channels available to exchange them between requestors and document sources. While greater efficiencies have been gained through the automation of requesting procedures, the disparate systems available result in a number of barriers to communication which include (Turner, 1990):

- ***an inability to exchange messages between different telecommunications networks.*** Examples are public electronic mail systems (ON-TYME II, ALANET), subject-oriented networks, networks specific to a geographic location (ILLINET, DOCLINE), and bibliographic utilities (OCLC, RLIN). Messages originating on one system cannot be sent to another system, and therefore there is a restriction in the flow of messages

- ***conflicting ILL message formats.*** Message formats vary with ILL networks, bibliographic utilities, and particular ILL software. The variance among message formats prevents automatic processing by dissimilar systems, regardless of whether they could exchange messages across telecommunications channels or not

- ***non-standardized message sequences.*** Other messages, in addition to the ILL request, need to be exchanged in order to complete the entire document delivery process, such as *shipped*, *received*, *renew*, *overdue*, and *recall*. The number, form, and sequence of these messages remain unspecified across ILL systems.

Furthermore, because these barriers prevent communication among disparate ILL systems, libraries are required to maintain subscriptions to more than one system to gain access to the full range of libraries that lend materials. For example, The Nebraska University Medical Center in the U.S. uses five different electronic networks to transmit ILL transactions resulting in increased work load, additional staff training, coordination of non-standardized networks, and determination of proper access protocols (Weaver, 1984). The ILL Protocol, now an international standard, addresses many of the interoperability issues involved with request management. Details of this protocol are discussed in Section 3.3.4.2.3.

While functions in the document delivery process to this point have been automated to a certain extent, the automation of the remainder of the process, namely, the retrieval and transfer of documents, remains largely based on traditional manual methods. The lack of automation in these areas represent the most severe interruption within the document delivery process.

2.2.4.3 Document retrieval

Although databases of electronic documents have recently begun to appear, such as the journal article image databases developed through projects such as ADONIS (see Section 5.1.2), the most common method of document retrieval remains the physical retrieval by library staff of print materials arranged on library shelves (Rice, 1990).

Current obstacles The predominance of paper-based document storage requires that a number of time-consuming and labour-intensive operations be performed at the document source. These manual operations include (Boucher, 1984):

- physical retrieval of materials from shelves by staff
- processing of materials through circulation and security systems
- manual photocopying of materials for mailing or faxing
- packaging and shipping of materials
- numerous clerical activities throughout the process, such as annotating ILL request forms.

These manual operations greatly reduce the speed with which a request can be filled.

2.2.4.4 Document transfer

The final delivery of a document, referred to in this study as *document transfer*, involves the forwarding of a document from a document source to a requestor and represents the least automated function in the document delivery process. The predominant method of document supply remains the transfer of paper-based materials through regular postal services. The British Library Document Supply Centre, for example, currently fills 60 per cent of its requests through regular post (Plassard, 1989). Special transport systems, such as courier services, may be used in addition to, or as a substitute for, regular mail, but these methods are still manual (Line, 1989a; Fjällbrant, 1988).

In the last 15 years, facsimile transmission has become an alternative to regular postal services for document delivery. Most fax transmissions are currently based on Group III telefacsimile machines. These machines typically have a resolution of 200 dpi and use regular analogue telephone networks as the transmission medium. While fax has also been used to transfer requests, the primary application is the supply of documents. Fax transmission has been found to be most useful when there is: 1) a large base of participants with fax machines; 2) a high volume of transactions; 3) usage over a lengthy period of time; and 4) when turnaround time requirements dictate immediate document delivery (Anand, 1987a; 1987b).

Current obstacles While reliable in most countries, regular post is extremely slow compared with the speed with which an item can be selected and requested. The time taken to deliver a document by this method varies with the distance between the requestor and the document source and there is the risk that materials will be lost or damaged in transit. Campus/intrainstitutional mail is also an option, but it is reported to be often very slow (Lynch, 1991a).

The speed of fax transmission does not usually vary with distance, however, faxes transmitted internationally are sometimes affected by line noise. Further, distance and the length of the document can seriously affect the costs of this method of transfer. In general, Anand (1987a; 1987b) found that:

- document delivery via fax is expensive compared to other types of document delivery

- fax transmission is not as effective or efficient for ILL messaging as electronic mail
- savings in human resources can be realized only if sophisticated enhancements (e.g., the availability of auto receive and deliver features and the possibility of transmission from bound volumes and microforms) are added to the fax unit.

Fax has been called "still much too slow and costly for regular use" (Line, 1989a:216).

Another problem, at least for Group III machines, is that the material often must be photocopied before transmission, requiring an extra manual step. Furthermore, at the receiving end the document typically is output on inferior paper and often requires another pass through a photocopier before it can be used (some highlighters, for example, will turn thermal paper black).

2.3 Technologies for electronic document delivery

The above examination has revealed a number of problems within the process of document delivery. The foremost problem is that the current document delivery process is incompletely automated—information about a certain document or request cannot flow through the process entirely in electronic form. For example, while the document selection and request management portions of this process have been automated, they are not interlinked in most automated systems. Thus, a citation found through electronic means must often be written out manually, and then returned to electronic form when it is submitted to an online ordering system or ILL subsystem.

Other portions of the process, particularly document retrieval and transfer, remain dependent almost entirely upon manual methods. Therefore, a request may arrive at a supplier in electronic form, but the primary document must be physically retrieved, photocopied, and sent by regular post to the requestor (or turned back into electronic form again if it is faxed, only to be printed as a paper document again at the requesting library). The overall process of document delivery, in this way, may be considered to be a *discontinuous* process that has within it many disruptions in the flow of information.

A second major problem is that participants in the process—requestors and document sources—remain for the most part isolated from one other. The variety of systems that support requesting, for example, are largely incompatible limiting the potential pool of document sources to which requestors have access.

There are a number of technologies and international standards available to address many of the problems that diminish the effectiveness of current document delivery systems. These technologies form potential "building blocks" of electronic document delivery systems that can be used to automate and integrate the various functions within the document delivery process. An EDD software application can theoretically automate the entire document delivery process and allow electronic information to flow throughout it without interruption. Further, the widespread use of peer applications over a network has the potential to interconnect a greater number of requestors and document sources. These technologies, discussed in detail in the following chapter, fall into five broad categories:

Electronic document conversion and generation A major problem in shifting from delivery of paper documents to electronic documents is the extensive body of print materials that libraries have collected that must be converted into electronic form. Scanning and optical character recognition (OCR) technologies which automatically put materials into electronic format can help speed the conversion process. Despite the use of scanning and OCR, the enormous volume of documents to be converted will make document conversion an expensive, time-consuming, and labour intensive undertaking far surpassing retrospective conversion projects of the 1970's and 1980's. A major obstacle for electronic document delivery in any form, however, is the issue of copyright—scanning existing copyrighted material without permission violates the copyright. See section 6.1 for more information concerning copyright.

Though the above technologies convert existing paper documents into electronic form, there is an increasing trend to generate documents in electronic format. This will be true during all stages of their development, from initial creation on word processors, through editing, to final typesetting or on-screen display. International standards available for document representation include Office Document Architecture (ODA), Standard Page Description Language (SPDL), and Standard Generalized Markup Language (SGML), as well as many proprietary formats such as PostScript.

Storage technologies Mass storage devices will be required to support the large image and electronic document databases that will form the basis of electronic document delivery systems. The primary candidates for these databases, already used to some extent, are optical storage devices, such as CD-ROM, WORMs, and Magneto-optical discs, that possess greater storage density and are less sensitive to deterioration or contamination than magnetic media.

Communications technologies and standards A number of communications technologies and standards are also emerging that will support the digital transmission of electronic documents. Communications options include high-speed LAN standards such as Fibre Distributed Data Interface (FDDI), Integrated Services Digital Network (ISDN) for "last mile" connections into homes, and research computer networks. Research networks are particularly interesting because they currently link academic and research institutions throughout the world and have been envisioned as the infrastructure that will support future electronic libraries. A major initiative in this area is the National Research and Education Network (NREN), a high-speed, high-capacity research network that is to be developed by the mid-1990's.

While the underlying physical network may be formed with one of the above options, the specific *tasks* supported will be accomplished through the development of higher-level services called *applications*—the actual services that are provided to end-users, be they human or machine. The ability of one application to communicate with another is an important element of electronic document delivery systems, as well as any other type of network application. One way in which such interconnectivity can be achieved is by basing applications on the standards for Opens Systems Interconnection (OSI). OSI refers to the automated procedures (protocols) that will allow the computers of different manufacturers to communicate with each other and share resources. However, because of the predominance of TCP/IP on major networks, especially those in North America, it is likely that real applications will have to support protocols in both the OSI and TCP/IP suites (Lynch, 1991a).

The specific OSI application protocols available to support electronic document delivery systems include X.400 for message handling systems, File Transfer, Access and Management (FTAM) and Document Transfer, Access and Manipulation (DTAM) for file transfer, the ISO ILL Protocol for ILL messaging, the X.500 Directory standard for directories, and the Search and Retrieve (SR) protocol for information retrieval. In addition, Electronic Data Interchange (EDI) standards are available to support the exchange of business records generated during a document transaction.

Workstation technologies The workstations that will serve as the gateway to future networked electronic libraries include high-end workstations (such as those based on Reduced Instruction Set Computing—RISC—architecture) using software environments such as X Windows and Motif.

Hardcopy production For the production of paper copies, standard and colour laser printers are available, as well as Group IV facsimile machines. For intensive document delivery operations, high-speed, high-quality printing systems, such as Xerox's DocuTech Publishing Series, may be more appropriate.

Chapter 3 will outline these technologies and international standards in greater detail, while Chapter 4 provides examples of the integrated application of the standards and technologies to overcome problems in the current document delivery process.

3. OVERVIEW OF CONVERGENT TECHNOLOGIES

The following provides an overview of the convergent technologies and standards that are available to create EDD software applications. These state-of-the-art and emerging technologies can be thought of as "building blocks" that can be used to construct an electronic document delivery system. As outlined in the previous chapter, these technologies and standards are categorized into the following areas:

- electronic document conversion and generation
- storage technologies
- communication technologies
- workstation technologies
- hardcopy production.

3.1 Electronic document conversion and generation

The two major methods of creating electronic documents are conversion, or the capture of a document's image in digital form, and the generation of documents in electronic format from the outset. The following subsections discuss both of these methods and their related standards and technologies.

3.1.1 Conversion of print and microform materials

Fundamental to all conversion of paper documents into machine-processable form is the capture of the image into an electronic representation. This process has come to be called *scanning* or *digitization*. Once an image has been digitized, various hardware and software transformations can be applied to it to compress the amount of storage required for an image, to convert the machine-specific encoding of the image into a standard format for storage or exchange, and to analyze the content of the image in order to reduce it to encoded text. The technologies available for transforming print and microforms into electronic form are discussed below.

3.1.1.1 Image scanning

Scanning is one of the techniques used to transform print and microform materials into electronic format (cf. Lynch and Lunin, 1991; Lynch 1991c). Image scanning is the process of creating an electronic representation of a physical document. Many librarians will be most familiar with the concept of scanning through its use as one part of the process of sending a facsimile image over a telephone connection. The techniques used for scanning have a long history, going back to the development of the wire-photo in the 1930's and preceding experiments from the turn of the century and earlier. The central device a *photo-sensor* which alters its electrical state when exposed to light.

Modern technology uses a photo-sensor called a charge-coupled device or CCD (similar to the sensor used in a video camera). When light, such as a bright light reflected from a page of text, strikes a CCD, an electrical charge is produced, and this charge can be used to generate an electronic signal, which can then form the basis of a single bit of information. CCDs can be made to be very tiny indeed, and current scanning devices use a row of hundreds or thousands of CCDs to analyze an image a line at a time. As the scanner passes over the page (or the page under the scanner, many lines are analyzed, to produce a matrix of dots, each with a discrete value of light or dark, that represents the page. These dots are often referred to as *rasters*, and the scanning process as *rasterization* or *raster scanning* (Lynch 1991c).

In the simplest scanners, each dot is recorded as being either light (white) or dark (black). This allows a single computer bit to represent each dot in the image. While this may be acceptable for printed text, which is normally monochrome and has very high contrast, this *bi-level* approach is inappropriate for tonal images such as photographs. More complex scanners thus recognize a range of intensities of light between white and black. (they use an analog-to-digital converter to break the continuous tonal variation of the original into discrete steps (like digital audio). Some recognize eight levels of intensity, and some recognize 16 or 256. Use of such a *grey-scale* scanner, unfortunately, increases the data generated in scanning an image substantially. To store information about eight different intensities or tonal values requires three bits per dot, and to store 256 different tonal values requires eight bits (one byte) per dot.

Scanners can be used to digitize colour images by splitting the light reflected from the document to go to three or four separate sets of CCD, each with a differently coloured filter. Thus one CCD would record the intensity of red light reflected from the dot, another would record the intensity of blue light from the same dot, another yellow, and the fourth the intensity of white. If each CCD distinguishes 256 different intensities, then 32 bits (four bytes) would be required to store the image for each dot.

It should be apparent that the smaller each dot, and the closer their proximity, the more accurate is the representation of the original image. The most common means of expressing this *resolution* is in terms of the number dots generated per inch (dpi) of the original image. Note that resolution measures two different things in the two dimensions of a flat original. In one dimension (across), it measures how closely the CCDs are packed in a line, in the other dimension (down), it measures how far the paper moves for each line scanned. It is therefore possible to have different resolutions for each dimension, although most vendors seek to avoid this.

Scanner resolutions typically range between 75 and 600 dpi, with 200 and 300 dpi being the most common resolutions. 200 dpi is often considered to be the minimum acceptable for consistently legible digitization of typewritten business documents. A scanner with resolution of 600 dpi is being used to scan documents for preservation withdrawal projects.

Higher resolutions, of course, increase the amount of storage required for an image. A 10 inch by 10 inch image scanned in simple black and white at 75 dpi will generate 562500 bits of information, or 70312 bytes; the same image scanned at 600 dpi in four colours with 256 intensity levels will generate 144,000,000 bytes of information before compression. It stands to reason that it will take longer to generate 144 million bytes than 70 thousand, although it will not necessarily take proportionately longer since higher resolution scanners will normally have more powerful processors and more sophisticated input/output channels. Nevertheless, while the average speed scanning a letter-size image using a 200 dpi bi-level scanner is 3-6 seconds (Unisys, 1990), high resolution colour scanning of the same image can take up to one hour.

In its basic form, all that can be done with a scanned image is to store it or display it again, either on a computer monitor, or by printing it onto paper or microfilm. Even simple display or reproduction, however, can require considerable processing and manipulation. The 600 dots in one inch of the original will occupy almost 20 inches on a 12 inch VGA monitor with a resolution of 400 pixels by 600 lines, and the same image printed with a 300 dpi laser printer will be twice the size of the original! The process of displaying or printing the image must therefore reduce the number of dots output according to the resolution of the output device, without losing too much detail of the original image, as well as compensating for distortions caused by differing horizontal/vertical ratios between input and output devices.

If the images are to form part of an electronic document delivery environment, however, additional processing will be required subsequent to scanning. The principal additional processing that may be required is data compression, format conversion, and possibly some form of optical character recognition (OCR). Image encoding formats and OCR are discussed below.

3.1.1.2 Image coding formats

For documents to be stored, displayed and transmitted by a computer system, they must be represented in electronic form. While all images are ultimately binary code, at a higher level, they can take a variety of formats. This subsection describes some available formats for encoding raster images. They differ in complexity, degree of compression attained, ability to represent colour, and degree of information loss.

Group 3 Group 3 (G3) encoding format, specified in CCITT Recommendation T.4, is perhaps the most commonly used today due to the ubiquitousness of G3 facsimile machines in the office environment. It supports both 1- and 2-dimensional image compression of black and white images, which can be quite efficient for relatively uniform images. The 1-dimensional compression scheme uses run-length encoding and can achieve compression ratios of 10:1 for office documents and 15:1 for engineering drawings. The resolution of G3-encoded images is 200 dpi (Katz and Cohen, 1991).

Group 4 Group 4 (G4) encoding format, defined in CCITT Recommendation T.6, is a fully 2-dimensional encoding scheme. It can achieve compression ratios of 15:1 for office documents and 20:1 for engineering drawings. Resolution of G4 images is 400 dpi. It is the scheme used for encoding raster images within ODA documents. Unlike G3, G4 assumes an error-free transmission medium, such as a data network, and is therefore not yet in wide-spread use (Katz and Cohen, 1991).

Tag Image File Format (TIFF) The TIFF was developed by Aldus and Microsoft as a common format for image scanner vendors and desktop publishing software. It allows for the transfer of multiple images by providing a method for their encapsulation within a file. TIFF is not a specific encoding format, but is a "framework for encoding techniques" allowing parameters (such as resolution) to be defined (Katz and Cohen, 1991:2). An open-ended format, based on the use of tagged fields, gives TIFF the flexibility to adapt to changing needs and to the specific requirements of particular equipment.

While standard TIFF allows for the encoding of grey-scale, palette-colour or RGB (red-green-blue) images, there are also two subclasses of TIFF: 1) TIFF-B, the format for bi-level, or black and white, images; and 2) TIFF-F, a proposed subclass of TIFF-B for fax images (Katz and Cohen, 1991). TIFF supports several compression schemes—one of the most popular is the Lempel-Ziv and Welch (LZW) (Welch, 1984) algorithm which can achieve compression ratios ranging from 2:1 to 10:1 for colour images. TIFF can also be used to encapsulate G3- and G4-encoded images.

Joint Photographics Expert Group (JPEG) The JPEG image coding standard, ISO 10918 (Wallace, 1991), is being developed by ISO and CCITT to achieve high compression of still black and white, gray-scale and colour images. It can operate in various modes, which in its most powerful, provides for compression ratios exceeding 15:1 for colour images. These compression ratios, using the Discrete Cosine Transform (DCT) (Rao and Yip, 1990), are achieved at the price of some loss of information, i.e., it is not possible to reconstruct the exact image once it has been compressed. A lower compression ratio of 2:1 also can be achieved without loss of information.

3.1.1.3 Optical Character Recognition (OCR)

OCR, or optical character recognition, is a method by which the textual content of scanned images is converted into character code thereby making the text available for manipulation. In the most common method for character recognition, called *template matching* or *matrix matching*, the bit-mapped image goes through a process that compares the bit-map of a target character with a set of stored bit-maps; if the reader finds the target font represented among its repertoire, then the target font is recognized, otherwise, it is not (Cahan, 1989).

The second method, called *pattern recognition* or *feature extraction*, is a more powerful method that analyzes the topological features of characters. It uses a number of algorithms or rules to go through a recognition process to identify the character. For example, an "O" contains 0 vertical lines, 0 horizontal lines, 1 loop, and 0 line endings, while a "D" contains 1 vertical lines, 0 horizontal lines, 0 diagonal lines, 1 loop, 0 line endings (Schein, 1989). A major advantage of this method is that the reader can be taught to recognize font types that it initially fails to recognize. The output of both processes is character code, such as ASCII.

The limitation of OCR technology is that the rate of accurate recognition must exceed 97 percent to be more efficient than manual re-keying (Walker, 1989). All errors produced in the OCR process must be corrected by hand. Factors that reduce recognition accuracy are poor paper or typeface quality: OCR systems require clean, crisp, black text on a white background to be most effective. Another limitation is that OCR technology also has problems with features of documents such as multiple columns, equations, diagrams, complex page formats, and ambiguous characters such as lowercase "l" and uppercase "I" in sans serif font styles such as Helvetica (Andre, Eaton, and Zidar, 1988).

Yet, there are distinct benefits in using this technique over strict image capture. First, the amount of storage required for each page is reduced significantly since only ASCII code is stored. Second, text-based tasks, such as information retrieval and automatic indexing, can be used on this type of electronic material. Typically, because of high error rates, projects that have begun mass digitization of print materials use a combination of bit-mapped images and OCR generated text to provide index access to the material. One such project is the National Agricultural Text Digitizing Project (Andre, Eaton, and Zidar, 1988). In this project, the documents were stored optically in bit-mapped form, while indexes for the images were created using OCR generated-text with indexing software. Pointers linked the index entry with the appropriate page images. This combination of text and images provides both information retrieval capabilities and the advantage of viewing an identical image of a document.

3.1.2 Electronic document generation

While the capture and storage of page images is required for that vast majority of the world's published heritage produced before the computer era, most documents today are generated through some electronic means. Computer typesetting and photolithography of computer-generated page images has now almost completely replaced the earlier mechanical methods of generating printed text; computer text editors and word processors of varying degrees of sophistication have largely replaced mechanical and electro-mechanical typewriters for originating documents or producing fair copies of manuscript documents; non-textual documents such as graphs, illustrations, and maps, are increasingly originated by electronic means.

Documents originated with the aid of a computer system have important differences from those captured by means of image scanning. Most notably, computer "originals" are generally stored as encoded text that can be subsequently manipulated by computer programs and users. Thus, in a text file, the letter "A" is not stored as an analogue of the graphic character, but as a code which represents the linguistic or logical meaning of the character. Because the code represents a meaning rather than an image, it can easily be processed by computer systems. Additionally, electronic originals will include some method for indicating structural elements of the text, such as headings and tables, and explicit instructions for producing human-readable output.

The elements of origination systems for electronic documents, *word processing*, *electronic markup*, *printer control languages*, and *page description languages*, are outlined briefly below.

Word Processing

For many computer users, word processing was the first computer application to which they were exposed, and text creation and manipulation has often been the application which has justified the initial acquisition of a computer system. A typical word processor allows the creation, manipulation, storage and printing of electronic documents. These documents are processed as character-encoded text, with additional instructions included that govern the output of the printed document as well as the display of the document on the screen. The additional formatting instructions are often held in the form of commands embedded in the text, in the form of special *control characters*. These commands are interpreted by an output *formatter* which generates the appropriate instructions for the output device.

In almost all word processing systems, the exact nature of the formatting commands are proprietary; that is, they have been devised by the implementor of the software, they are exclusively for use with that software, and they are generally not understood by other software. Thus, documents generated by one word processing system can, in general, be viewed, manipulated and output only by other instances of the same software. In addition, most word processing systems are designed to control only the format, or appearance of a document. They are used to generate text in a certain style, with a set line length and page size. The fact that the appearance of a document is largely a function of its structure is more or less ignored by many word processors.

Electronic markup

The inclusion of formatting instructions in a document is often referred to as *electronic markup*—an analogy to the marking up of a paper manuscript by a publisher's editor prior to it being sent to the printer. Some word processors perform this markup invisibly to the user; the user invokes the appropriate command, and the appearance of the document on the screen immediately reflects this command. This approach is generally referred to as "What You See Is What You Get" (WYSIWYG). WYSIWYG gives an electronic author or editor a very high degree of control over the final appearance of a document, but at the cost of significantly reduced processability of the markup instructions.

In a WYSIWYG system, for example, one chapter heading may begin with a bold instruction, followed by a centre instruction, followed by a 24-point instruction. Another heading might have a different order, beginning with the 24-point instruction followed by the bold instruction followed by the centre instruction. Although the two sequences of commands will achieve an identical result, it will be difficult for both to be recognized as indicating a chapter heading, and the structure underlying the format of the document is obscured. Most of the popular PC-based word processing systems are based on the WYSIWYG approach

An opposite approach uses explicit markup commands to control the output format of the document. Here the user generally does not see the final format at initial input. Instead, the user inserts explicit formatting commands in the text at the appropriate point. A number of such commands can often by referred to by a single abbreviation or *macro*, so that a "chapter heading" command will cause the output text to be centred in bold, 24-point type. The UNIX *nroff* and *troff* text formatting programs are well-known examples of this approach. The strength of this approach is that it permits the structure of the text to form the basis of the output format. Once the structure of the text is encoded, then it can be further manipulated, allowing, for example, the automatic creation of indexes or tables of content, or the automatic recognition of data elements in the text to allow inclusion in a full-text or other database.

Both WYSIWYG and explicit markup approaches, however, remain proprietary, and are ultimately intended primarily to produce formatted, final-form documents. In order to be able to exchange documents between computer systems that may be using different, mutually incompatible, software, a standardized exchange format is required (discussed in Section 3.1.2.1).

Printer Control Languages

In order to produce printed output, most word processors issue specific commands to computer printers, commands like "move margin", or "change font". These commands are often in the form of an *escape sequence*—an escape character followed by one or more codes that indicate the instruction to be performed, together with any parameters for the instruction. These commands are specific to individual printers, or to families of printer from a single manufacturer. As printer capabilities and user requirements for high quality output have become more sophisticated, these *printer control languages* have become more powerful and more complex. In fact, the creation of *printer drivers*—interfaces between the application software and a specific printer—has become a substantial part of application development.

Some printer control languages have become quasi standards for printer design. The Epson printer control language, for example, has been widely used by many manufacturers of dot-matrix printers. Similarly, the printer control language used with Hewlett-Packard printers, HP-PCL, which has a number of levels of sophistication for use with printers of different capabilities, is supported by many laser printer manufacturers.

Page Description Languages

A page description language is an attempt to remove the necessity to create multiple printer drivers for an application by defining a standard way of interfacing with an output device. In general, a page description language is a programming language that is used to specify precisely the location and nature of graphical elements on the output page. This program is sent to the printer (or another output device), that contains a computer processor and software enabling it to interpret the program and produce the printed page as described. A printer driver for a page description language device, therefore, is a program generator, and the programs generated can be interpreted by any device that understands the language, regardless of manufacturer.

An additional advantage of page description languages is that the output device always operates at the best resolution available for the device; the application software generating the program does not need to specify a resolution, or behave differently for a dot-matrix printer as opposed to a typesetting machine; the single program is interpreted by both.

The best known page description language is PostScript, a proprietary language developed by Adobe Inc., and widely implemented on many different kinds of printer. More recently, Display PostScript has been developed to allow pages to be created on other output devices, such as graphic terminals. Another example of a page description languages include Interpress, developed by Xerox.

3.1.2.1 Exchange formats for electronic documents

All the document formats and encoding schemes described above are primarily intended for use in a single computer system, in which the user has control of both input and output and can use the hardware and software that is most appropriate for local needs. In a networked environment in which documents are exchanged electronically, however, the user must also be aware that the recipient of the document is likely to use a different system, with a different hardware platform, and different software. This heterogeneity of equipment requires ways of representing documents for exchange that are independent of the configuration of the system on which the document was created.

There are two broad forms in which a document can be exchanged: 1) a *revisable form*, in which the recipient can alter the content and/or structure of using his or her local system; and 2) a *final form*, which the recipient is not intended to alter, but only to print or display. Of course, any computer file can be altered if the recipient is prepared to go to sufficient trouble, but the terminology indicates the intention of the sender, and the ease with which alterations can be made. Some general formats for document exchange are discussed briefly below.

Unstructured Text

The simplest means of transferring a revisable form document is to send a file of character strings, with no structural or formatting information at all. Even this, however, is not a fully general solution. There is first of all a character encoding problem—not all computer systems use the same encoding scheme. In particular, IBM mainframe systems use EBCDIC encoding, which is incompatible with the ASCII encoding used on most other platforms. Furthermore, there are national variants of the ASCII encoding scheme which can result in misinterpretations of codes between disparate systems. For example, a pound-sterling symbol in one system can become a hash-mark in another. Even when the same encoding is used, there is no standard to indicate a line end—some systems use a carriage return/line feed pair, some use only a carriage return or line feed.

The unstructured text approach, though common, cannot be used to transfer anything other than simple text; more sophisticated elements, such as diagrams, tables, and page layout, cannot be included.

Proprietary Formats

If proprietary hardware and software becomes sufficiently ubiquitous, then it can be used as a *de facto* standard for exchange. Thus the 5.25 inch diskette is widely used for transferring data files between systems. Similarly the WordPerfect word processing software is sufficiently widely used, at least in North America, to enable its proprietary format to be used as an exchange format for revisable texts between many sites; most other word processing software can at least convert from the Word Perfect format.

As another example, the PostScript language has been widely adopted as a standard for the exchange of final-form documents. The fact that the language is independent of the output device enables it to be supported by a great many sites that are otherwise quite incompatible.

International standards for structured documents

While there are many proprietary formats for encoding, marking up, and laying out documents, it is apparent that such formats cannot be readily exchanged and processes by incompatible systems. There are, however, international document standards available to facilitate computer-based authoring and typesetting and to ensure that such documents can be readily interchanged. These standards include Standard Page Description Language (SPDL), Standard Generalized Markup Language (SGML), and Office Document Architecture (ODA), discussed below.

Office Document Architecture (ODA) Office Document Architecture (ODA) is a method of specifying the content, logical structure *and* physical layout of a document (Dawson and Neilson, 1990). The specific aim of ODA is to facilitate the interchange and remote access to documents (Radlett, 1988). The standard is used to define complex, structured documents that can simultaneously contain text, graphics, sound, still images, and even moving images. The ISO standard for ODA is ISO 8613, Parts 1-8.

Essentially, documents produced using ODA can come in three forms: 1) the *processable form*, or revisable form, that permits the recipient to process further both the content and format of the document; 2) the *formatted processable form* that has its format fixed but allows the recipient to modify the content; and 3) the *formatted form*, or final form, unmodifiable by the recipient and ready for printing on-screen or off.

ODA representations have two distinct advantages over other representations. One, all aspects of a document needed for most tasks, such as information retrieval, automatic indexing, printing on-screen or on paper, are contained in a single document. Two, any of the three document forms outlined above can be transmitted depending upon the task for which it is needed. For example, the processable form may be exchanged between authors for further modification and the final, formatted form may be distributed to end-users.

It should be noted, however, that the ODA standards are for "office documents". Scientific and technical material, with its large amount of tabular material and complex formulae, does not fit will into the model or the interchange format. The ISO Standards Committee is investigating extensions to ODA to provide for such capabilities (MacKinnon, 1991a).

Standard Generalized Markup Language (SGML) A step up from ASCII representations ares those that have elements of the logical structure of a document, such as headings and subheadings, identified within the body of the text. Standard Generalized Markup Language (SGML) is a device-independent, process-independent ISO standard for adding "tags" identifying these elements (Wu, 1989). Other types of content elements, or *entities*, include headings, chapters, paragraphs, and appendices.

SGML also allows for general rules that describe specific types of documents. These rules define the entities allowed in a given document type as well as the relationship among the entities. For example, a journal article can be defined as having a title, an author name, an abstract, an indeterminate number of headings and paragraphs in the body, followed by references.

Tagging documents with SGML simplifies both information retrieval and automatic indexing of full text as the significant entities used in these processes are explicitly identified. Note, however, that SGML does *not* describe the actual *layout* of a document. The ISO standard for SGML is ISO 8879.

SGML has been widely adopted as a markup standard within the publishing industry, and many electronic texts are now available with SGML encodings. Examples of SGML use include the SGML tagging of the Oxford English Dictionary (Painter, 1988) and the choice SGML as the markup language in the Text Encoding Initiative. The purpose the Text Encoding Initiative is to provide guidelines for the SGML encoding of electronic texts, specifically in humanities research (Sperberg-McQueen and Burnard, 1990).

Standard Page Description Language (SPDL) Almost the opposite of SGML, Page Description Languages (PDL), such as Adobe's *PostScript*, define the layout of an electronic document but not the content; they specify the exact manner in which a page should appear when printed. They tell the printer how to size and position minute elements, such as lines and curves, that will form the fonts and graphic elements on a page.

The ISO standard, Standard Page Description Language, is an attempt to create a PDL that is not exclusively tied to a specific text generation package or printer (Robinson and Strasen, 1989). It is important to note that documents defined with a PDL are in a final, non-processable form; that is, they cannot be readily manipulated or modified as can other electronic representations, useful in cases where the recipient has no need to modify the document.

3.1.3 Multimedia documents

One other type of document that may have eventual importance in electronic document delivery, though not focused on specifically in this paper, are multimedia documents. Multimedia documents are electronic documents that link text, graphics, images, speech, audio recordings, animation and video into one unit (Chen, 1989). There are a wide variety of formats for multimedia, and systems to manipulate them, and general standards have yet to stabilize. Standards for multimedia are needed in four main areas (Alexander, 1991):

- application programming interface to multimedia hardware
- a file format for exchanging files across different platforms
- compression algorithms for audio
- compression algorithms for still and full-motion video

Competing standards for aspects of multimedia documents and interfaces include, for example, JPEG, an encoding scheme for still images discussed above, the Moving Picture Experts Group (MPEG) which operates within ISO to develop a standard for the compressed representation of video images and the associated audio signal (Le Gall, 1991), and Digital Video Interactive (DVI) which deals with full-motion video using both extensive compression and real-time decompression techniques (cf. Ripley, 1989), and Compact Disc-Interactive (CD-I).

Exchange of multimedia documents

Regardless of which system configuration and document format become the standards for multimedia, this type of document will no doubt form part of the collection of electronic documents that will be exchanged through a network. Once standardized, multimedia documents, as self-contained units of information capable of being processed off-line (as opposed to interactively), can be exchanged in two ways: 1) as a file through a file transfer application like FTAM; and 2) as an enclosure in a message in a message handling system, such as X.400 (Bauerfeld and Westbrock, 1991). For more information about FTAM and X.400, see Section 3.3.4.

3.2 Optical storage technologies

Optical storage technologies have certain advantages over the traditional magnetic storage technologies such as magnetic tape, floppy disks and hard disks. The most notable advantages of optical storage include:

- a greater storage density
- less sensitivity to electromagnetic fields
- less susceptibility to physical damage in the read/write device
- easy loading and removal.

The greater storage density is the main advantage of optical storage—much more information can be stored on an optical disc than on a comparably sized magnetic disk. This is primarily due to two factors: 1) the tracks on an optical disc are recorded much closer together because a laser can be focused more precisely than a magnetic recording head; and 2) the physical space required to record an optical bit is much less than that required to record a magnetic bit.

Optical storage has a number of advantages over magnetic storage:

- they are less sensitive to deterioration or contamination as nothing touches the active recording layer except a beam of laser light
- they are less susceptible to head crashes compared to magnetic disks
- they are easily loaded and removed allowing them to be used in "jukebox" configurations with massive storage capacities.

For the reasons mentioned above, optical disc storage merits consideration as a mass storage medium for electronic document delivery. Optical disc storage comes in three forms: CD-ROM, WORM (write once, read many times) and re-writable magneto-optical (MO). A brief discussion of jukebox technology is also provided below.

3.2.1 CD-ROM

CD-ROM uses technology and standards developed by Philips and Sony for the audio recording industry to store large amounts of digital data. This optical technology uses a laser to read raised ridges or hills (representing data bits) on a reflective face.

Compact discs are replicated in much the same way as vinyl phonograph records, using injection molding into pre-mastered dies. Like records, CDs are expensive to master (a few thousand to tens of thousands of dollars), but the marginal cost of manufacturing copies is low ($2 to $10 U.S. depending on quantity). CD technology is in this respect similar to printing technology where origination and typesetting costs are high and the cost per copy is low. These cost factors, combined with the major limitation that the information on CD-ROM discs is fixed and cannot be altered by the user have caused CD-ROM to be used primarily for publishing large amounts of information that is updated infrequently.

CD-ROM offers many benefits over traditional magnetic storage media for publishing applications. It is highly portable; each disc takes up no more space than a floppy diskette, yet it stores up to 660 MB of data—approximately 250,000 pages of text of 40,000 pages of images. Unlike floppy disks, it is not affected by magnetic fields. CD-ROMs, however are not indestructible, and they have a definite life span. Recent research into the chemistry of polymers suggests that the "safe" life span may be as little as three years, although anecdotal evidence from CDs used in the audio industry suggests that an average life span of over 10 years may be a reasonable assumption. It should be noted, however that longevity of the medium is not the primary issue; of equal or greater importance in archival use of CD-ROM and other digital technology is the continuing availability of equipment to read the medium; A CD-ROM could have a lifetime of 1000 years and still be worthless after 10 if the CD-ROM player is no long available. A disadvantage of CD-ROMs that should be noted is that a CD-ROM drive's average access time is approximately 500 milliseconds, which is slow in comparison to hard disk access times of around 20 milliseconds. However, in comparison to a serial search of magnetic tape, this is very fast.

Compact discs, whether carrying digital audio or computer data, are standardized to 120 mm (4.724 inches) in diameter. The *coloured book* standards produced by Philips and Sony ensure compatibility between drives, which means that CD discs are readable in all players. The *High Sierra* standard for CD-ROM, formalized as ISO 9660, describes the filing and directory structure for computer data on CD-ROMs.

The major compatibility issue surrounding CD-ROM is the fact that each publisher uses a different proprietary search engine, each of which has a different user interface. According to the Optical Publishing Association, about 40 proprietary schemes are available to encode and index the data on a disc (Lockwood, 1990), with each retrieval software program using its own method to read the information. To a large extent, this is a marketing issue, with each vendor using its search engine and user interface to create a brand identification. It causes problems for users however, particularly in libraries, where many CD-ROM are available for use, each with a different search engine that requires training and support.

3.2.2 WORM

WORM (write once, read many times), as the name suggests, is a blank optical medium that can be written to once and then read from many times, as with a normal CD-ROM. WORMs allow optical discs to be produced inhouse, rather than by having to use costly disc mastering services. WORM is ideal for storage of large amounts of custom data that does not need to be updated often.

WORM drives come in a variety of sizes and constitutions, for example, 5.25-, 8-, 12- and 14-inch WORM drives are available. The storage capacity of a 5.25-inch disc varies from 300 to 600 megabytes per side. The capacity of a 12-inch disc is typically 1 gigabyte per side. A 14-inch disc can hold over three gigabytes per side. WORM "jukeboxes" (see below) are available that can hold more than 1 terabyte (1 million megabytes). Like CD-ROM drives, average access times of WORM drives are around 500 milliseconds.

There are many different WORM drive designs. In some designs, to write information, a strong laser pulse causes local vaporization of an active layer forming a bubble in a thin absorbing layer. In other designs, the laser "burns" a pit in an active layer exposing a highly reflective material. In both designs, information is retrieved by reading the resultant change in reflectivity of the beam caused by the presence or absence of a pit or bubble.

A major drawback of current WORM technology, however, is that there is a lack of standardization among WORM drive vendors—data written on one vendor's drive usually cannot be read on another's drive.

3.2.3 Magneto-Optical Disc

Magneto-optical (MO) disc drives are the first *erasable, re-writable* optical storage device. Although CD-ROM and WORM drives are ideal for certain applications, erasability and re-writability allows MO drives to function as general purpose storage devices.

MO drives have a storage capacity of up to 650 megabytes (2 sides of 325 megabytes each). Jukeboxes are available that store 30 to 50 gigabytes on-line and provide access to any file in 10 seconds or less. Access time for MO disc drives is around 100 milliseconds, which is about six times slower that for a high-performance (17 millisecond) hard disk drive.

MO disc drives use the standard 5.25-inch form factor with the optical media housed in removable cartridges that include a write-protect tab to prevent unintentional erasures. The 5.25-inch cartridges are promised to be interchangeable. In addition, 3.5- and 2-inch formats are under development.

MO discs combine laser technology with traditional magnetic technology. The active recording layer consists of a rare earth/transition metal alloy sandwiched between two transparent dielectric layers. The active recording layer is magnetized. Depending on the direction of magnetization, light reflected by this magnetic layer has a rotation of polarization (known as the Kerr effect). It is this rotation of polarization that indicates whether the bit read is a 1 or a 0. To change the direction of magnetization of the active layer, a pulse of laser light is focused on the layer while a small magnet on the opposite side of the disc produces an external field opposite in direction to the original magnetization. At the high local temperature, the magnetization is reversed and then fixed with equally rapid cooling.

The advent of MO disc drives does not mean the end of magnetic disk drives. Magnetic fixed-disk drives still have a speed advantage and, for the foreseeable future, will continue to be used for fast-access storage of frequently accessed code and data (perhaps 100 megabytes for the operating system and application programs). MO storage is ideal if a large amount (hundreds of megabytes or more) of on-line, re-writable and interchangeable storage is needed at a reasonable cost (Rosch, 1990).

3.2.4 Jukebox technology

Optical jukeboxes, similar to their café namesakes, are devices that house a large number of discs and allow for their automated selection, retrieval and playback. There are many jukebox types, holding various sizes of WORMs or CD-ROMs, and operating with one, two, or four internal disc drives. Jukeboxes provide automated access to very large amounts of electronic data. A Kodak jukebox, for example, housing 14-inch optical discs, can store more than a terabyte (a thousand gigabytes) of data. IBM has also introduced a 5 1/4 inch WORM jukebox, called a WORM Optical Library Dataserver, that is capable of storing 300,000 to 3.2 million page images. Optical jukeboxes can have a disc exchange time of less than three seconds (Banet, 1991).

3.3 Data communication technologies

The following section provides an overview of data communications technologies that are available to create electronic document delivery systems. The technologies discussed range from simple facsimile, which combines image scanning technology with data communication technology, to more complicated network technologies that can support sophisticated EDD applications, including state-of-the-art, high-bandwidth Fibre Distributed Data Interface (FDDI), Wide-area Network (WAN) technologies, and communications infrastructures such as academic and research computer networks.

The application protocols that can be used to construct EDD software applications are also included in this overview of communication technologies. *Application protocols* are specific statements regarding the rules and formats that communicating applications must follow to perform the desired function. An overview of the two major protocol suites that will likely have an impact upon developments of document delivery applications—TCP/IP and Open Systems Interconnection (OSI)—is provided.

Most network administrators have expressed a commitment to migrate to OSI protocols, however, TCP/IP will probably continue to be a major force in networking for some time (Rose and Cass, 1987). Because TCP/IP and OSI protocols will likely have to coexist in some fashion, this section provides a discussion of OSI and TCP/IP coexistence and transition.

3.3.1 Some important networking concepts

It is important initially to define a few concepts that will be useful in subsequent discussions of data communication technologies. These concepts include the peer-to-peer network, the client-server model, channel capacity, communications protocols, and the OSI Reference Model.

Peer-to-peer networks and the client-server model

A peer-to-peer network is a network of independent computers that are capable of communicating and sharing resources, with the full processing power of each computer available for use. Each computer is considered to be equal to, or the *peer* of, any other computer regardless of type or size. (This is in contrast to a *terminal-to-host* network which connects "dumb" terminals with little or no processing power to a central computer host; the terminals act as simple input and display devices for the central computer.) The important characteristic of peer-to-peer networks is that they are general communications infrastructures that manage and support any number of tasks between remote systems and users. Such tasks include exchanging electronic mail messages, transferring files, participating in electronic conferences, accessing databases, and logging in to distant computers.

The procedure by which two computers cooperatively accomplish a task is based on a *client-server* model. The computer at the user's end of the network acts as a *client* of the services provided by the remote computer, or the *server*. The client system sends messages containing requests which are responded to by the server system. The servers control access to the shared resources, such as filing systems, printers, and communications subsystems, and perform functions such as searching and updating databases, and ensuring the integrity of the information they manage. The client/server model has several advantages over the older centralized model. It is possible to have a single client that interoperates with multiple servers, all invisibly to the end user. The user need only learn a single user interface, that of the client application. The client and server communicate through standardized interfaces, or protocols, so that the complexity of the server is hidden from the client, and vice versa. Communication costs are reduced because whole packets of information are transmitted, rather than the single characters typical of terminal-based communication.

This model is used most typically in Local Area Network environments, but is applicable as well to wide area networking when there is a clear distinction between the roles played by the communicating parties. The fact that both the client and server systems have significant computing capability distinguishes this form of computing from centralized models where all computing power is centralized and user access is via relatively unsophisticated terminals.

Channel capacity

Another important concept in data communications is *channel capacity*—the measure of the maximum rate at which information can be transmitted over the channel without error. For data communications purposes, channel capacity is measured in *bits per second* or *bps*.

> ***Bandwidth*** One of the factors that influence a channel's capacity is its *bandwidth*. Bandwidth is the capacity of an analog line. It is measured by the range of frequencies that the line is designed to carry. Frequency is represented in *Hertz* (Hz), the term used for *cycles per second*. It has been proven that a channel's capacity to transmit digital data is directly proportional to the channel's bandwidth. Of course, there are factors in addition to bandwidth that also affect a channel's capacity such as channel noise and distortion. The effects of limited bandwidth on channel capacity, along with the effects of noise and distortion, are described in detail in Martin (1988). As an example, the bandwidth of a normal telephone line is approximately three kiloHertz (kHz). Over such a line, the maximum practical speed is 9600 bps. There are modems capable of operating at 19,200 bps, but they always have automatic fallback schemes to drop the modem to a lower speed if the line is less than perfect.

Channel capacity in electronic document delivery is important, especially when images are transmitted over communication channels. Consider, for example, the situation where many libraries provide connections to bibliographic utilities via 1200 or 2400 bps dial-up modem channels. Transmitting a full screen of text (about 2000 characters) at 1200 bps (at 10 bits per character including two bits for low-level synchronization) will take about 16 seconds, and about eight seconds at 2400 bps.

If, however, the document contains a full screen image, the information will take much longer to transmit. Using the IBM VGA standard display as an example, a full screen image has about 300,000 pixels (640 X 480 pixels). If 10 bits per pixel are used to represent colour and other attributes, approximately 3,000,000 bits are needed to represent an uncompressed full screen image. The transmission of such an image at 2400 bps (at 10 bits per byte) would take about 27 minutes! Of course, protocol overhead can act to increase transmission time, while data compression can reduce it. In any case, this example demonstrates the need for higher bandwidths in electronic document delivery, especially for the transmission of images.

Because electronic document delivery applications will require high-capacity data communications, only those network technologies that can support such fast data exchange are discussed in this section.

Protocols and the OSI reference Model

A third important concept is that of protocols and the OSI reference Model. In the diplomatic world, a protocol is a set of formal rules specifying how business is to be conducted between sovereign states. Similarly, a protocol in the computer world is a set of formal rules that specify how to conduct business between independent computer systems. These rules in both worlds are designed to ensure that communication is not impeded by misinterpretation of words or deeds because of system differences. Thus, a communications protocol will specify both the broad terms of what services one computer system can expect to be available from another and also the minutiae of what kinds of data may be exchanged together with its order and syntax.

The OSI Reference Model The protocols in a protocol suite can be described according to the placement within what is known as the *OSI Reference Model.* An outline of this model will be helpful for the discussion of application protocols suitable for a document delivery application, therefore, a very brief listing of the layers in this model is presented below. For a more detailed discussion of this model, and of networks and networking technology in general, please see Report #1 of the *UDT Series on Data Communication Technologies and Standards for Libraries* entitled *Research Networks and Libraries: Applications and Issues for a Global Information Network.*

The OSI Reference Model has seven layers which are:

- ***Physical layer*** The first or lowest layer is the Physical layer. It is at this layer that bits of data are passed from a computer to the wire or other physical connection between machines, and then back from the wire to a computer.

- ***Data link layer*** The second layer, the Data Link layer, accomplishes the error-free exchange of data between two directly connected systems.

- ***Network layer*** While the first two layers handle exchange of data between directly connected, adjacent systems, the third layer, the Network layer, provides services that enable systems anywhere to exchange data.

- ***Transport layer*** The Transport layer, layer 4, is the first in which data is transparently exchanged between end systems; all the lower layers may involve the processing of data by intermediate systems to ensure, among other things, proper routing and error correction.

Above the OSI transport layer are the three upper layers of the OSI model: the *Session layer*, the *Presentation layer* and the *Application layer*.

- ***Session layer*** The Session layer adds structure to the connection provided by the Transport layer.

- ***Presentation layer*** The Presentation layer ensures that information is transferred in a form mutually intelligible to different, possibly incompatible computer systems.

- ***Application layer*** The Application layer is the highest, and most complex, layer of the OSI model. It is important to note that the Application layer does not specify what applications are to be available to a user of a computer system, nor how any particular implementation should appear to a user. Rather, the Application layer specifies what communications services are to be available to a computer system for a number of specific purposes.

  Application layer protocols can be used in combination to provide any given computer application with the communication services it requires. Thus, there is no need to specify an indefinite number of protocols for each specific application. Instead, the combination of a few more or less generic protocols will normally be sufficient. Some of these protocols may be available for direct use by an end-user program, whilst others, which provide common services, will only be used by other protocols and the end-user will be largely unaware of their existence.

3.3.2 Facsimile

Facsimile (or fax) provides the capability for a document to be scanned and transmitted by a fax machine at one location, and received and printed at another location that has a compatible fax machine. Most fax transmissions occur over standard voice-grade telephone lines allowing them to be sent anywhere in the world where telephones exist. While fax machines are now commonly used by many businesses in their day-to-day operations, they are also becoming an increasingly popular tool of the 1990's librarian (Walton, 1990). Librarians use fax machines to send acquisition orders, request and receive interlibrary loan (ILL) materials, and communicate administrative matters, and thus, for the near-term, fax will continue to play an important role in electronic document delivery.

A fax machine is an image scanning, communication and printing device all in one. Fax machines use image scanning technology (described earlier in Section 3.1.1.1) to capture the page to be transmitted. Fax has no place within the OSI model. It is primarily intended for human operation. It has a number of limitations including: 1) the most common standard, Group III fax, provides poor-quality reproduction of originals; 2) it offers little or no security of data; and 3) it requires the use of expensive voice-grade telecommunications. Yet, its use has become almost ubiquitous in the business world and will remain an important factor in document delivery technology for many years to come.

CCITT fax standards

There are four groups of CCITT standards which establish the machine protocol and transmission techniques for a particular class of fax equipment. The standards specify details such as the direction of scanning, the size and number of scan lines, data-compression techniques, as well as phasing. The major characteristics of Groups 1, 2 and 3 are:

- ***Group 1*** operate at six minutes per page using analog frequency modulation transmission; a four minute per page speed is a manufacturer's option.

- ***Group 2*** operate at three minutes per page using analog amplitude modulation; a two minute per page speed is a manufacturer's option; the minimum resolution is 96 by 96 dots per inch (dpi).

- ***Group 3*** operate at one minute or less per page and use digital techniques to enhance speed including redundancy reduction and bandwidth compression; the minimum resolution is 204 dpi horizontally by 98 dpi vertically. These standards are designed to support communication over normal voice-grade telephone lines. Group 3 machines include a 9600 bps modem (CCITT V.29) to permit timely transmission of document pages, but this is nevertheless carried out over voice lines. There is no mechanism for sending faxes to these standards over other network services such as X.25 or the Internet; neither is there any standardized mechanism for scanning images prior to establishing the connection.

- ***Group 4*** Group 4 fax, on the other hand, is designed for use in data networks. It can therefore be carried over dedicated leased lines, X.25 networks, and ISDN networks. Group 4 fax images can be transmitted using X.400 electronic mail, and can be included in other image transfers as a TIFF-defined format. The connection options available with Group 4 are thus much more flexible than with the earlier fax standards.

  Group 4 products have begun to emerge, with machines from Canon, Fujitsu, NEC and Ricoh already on the market. These products generally provide higher speeds, higher resolutions and a number of new capabilities, including store-and-forward message handling, computer interfacing, and intelligent copier features using laser printer engines. As an example, Canon's FAX-L6500 Group 4 (and Group 3 compatible) fax provides 400 by 400 dpi resolution using plain paper and transmission speeds as fast as 1.5 seconds per page (Skvarla, 1989). A current disadvantage of these devices is that they require two access lines, one to a high speed digital network, and the other to a normal voice-grade telephone network to communicate with the enormous installed base of Group 3 machines.

Group 3/D

The above limitation has stirred interest in the development of a digital version of Group 3 facsimile, termed G3/D. A proposal is currently being considered by CCITT Study Group VIII to enable Group 3 transmissions to occur at speeds up to 64 Kbps over digital access lines and then, once in the public network, to communicate with either Group 3 fax machines linked to the network over analog access lines or other G3/D fax machines. G3/D units, as initially envisioned, would not be able to communicate with Group 4 systems.

In 1988, Group 3 made up about 90 percent of the installed fax machines.

The benefits of this approach are the reduction of access lines to one, simpler handshaking between systems, and the elimination of the requirement to support both Group 3 and 4 capabilities (as is needed in the current generation of Group 4 products). However, at this time, the future of G3/D remains clouded, since its acceptance by the CCITT community seems far from assured.

Fax boards

Personal computer (PC) fax boards are also available which allow a PC to act like a fax machine. With such a board, incoming fax transmissions can be stored on the PC as files, displayed on the computer's screen and if desired, printed. To send a fax, documents created online using a word processing, graphics, or spreadsheet program are first converted into a format recognized by the fax board and then transmitted. Unless the PC is equipped with a scanner for scanning paper documents, the fax board is limited to sending documents created online.

3.3.3 Network technologies

Fundamental to electronic document delivery is the availability of, and widespread connection to, an appropriate telecommunications infrastructure that allows documents to be delivered to the user in a timely, affordable manner. Such an infrastructure is currently well on its way to implementation, although only certain sectors of the library community, such as academic libraries, currently sufficient connectivity for large-scale document delivery. The following sections briefly describe some of the underlying technologies and standards.

3.3.3.1 High volume data transmission

Most of us are aware of the use of modems to transmit digital data over common voice-grade analog telephone lines. As discussed earlier, this method of transmission is limited to 19,200 bps without special devices. This section examines the emerging higher capacity data transmission technologies, such as frame relay and ISDN. Some of these technologies, such as Switched

Multimegabit Digital Services (SMDS) and Fibre Distributed Data Interface (FDDI), are restricted to use within a limited geographic area and are referred to as Local Area Network (LAN) or Metropolitan Area Network (MAN) technologies. Others offer potentially global data transmission, and are known as Wide Area Network (WAN) technologies.

Leased Lines

The term *leased lines* (or *dedicated circuits*) refers to communication channels leased on a semi-permanent basis from a telecommunications operating company, or PTT (national Postal, Telephone and Telecommunications authority). Leased lines provide point-to-point connections on channels of a known and fixed capacity or *bandwidth*. This capacity is available (and must be paid for) whether or not it is used. A very wide range of bandwidths is offered by communications companies, ranging from 1200 bps to 45 Mbs and higher.

Leased lines are very commonly used in the United States, where they are relatively inexpensive. They are less commonly used in other countries where telecommunications policy has made them more expensive than other approaches.

North American digital lines are generally referred to by a "T" number. The T1 carrier is a high-speed digital transmission system providing 1.544 Mbps on copper wires. T1 was designed for use in the public telephone network to implement connections between switching offices. T1 lines are now readily available for lease by private customers. The cost is dependent on the distance between the two connected points and is generally thousands of dollars per month. These lines are economical in situations requiring constant, high-speed data transfer.

One important use of high capacity leased lines is to interconnect LANs at remote sites. These leased lines form the "backbone" of a private Wide Area Network.

Some customers requiring very large data transfer capacities are leasing T3 lines, which offer a transfer rate of 45 Mbps and cost tens of thousands of dollars per month. T3 lines now form the backbone of the U.S. NSFNET.

Synchronous Optical Network (SONET)

SONET is an emerging standard for high-speed fibre-optic data transmission systems. It defines a line rate hierarchy and frame format for use with optical fibre transmission systems. Various levels of SONET will offer data transfer rates from 51.85 Mbps to 2.5 Gbps. SONET is a standard at the OSI physical layer; FDDI, IEEE 802.6 and SMDS can all operate over SONET networks. Synchronous Digital Hierarchy is an international version of SONET.

Integrated Services Digital Network (ISDN)

The Integrated Services Digital Network (ISDN) is a set of communications standards aimed at the creation of a global telecommunications network supporting a wide range of voice and non-voice applications. For the user it offers the possibility of carrying both voice and data simultaneously over a single physical connection, providing an inexpensive, universally available data network.

ISDN has evolved from the existing Integrated Digital Network for telephone communications. In this latter, network all data transmission is digital, except for the initial connection between the customer and his/her local switching office ("exchange"), and the final connection between the called customer and his/her local exchange. The intention of ISDN is to make these final two connections digital as well.

While the standards involved in ISDN are both numerous (78 CCITT Recommendations) and complex, two fundamental levels of service have been defined. The *basic access* service provides a user with two 64 Kbs B channels (bearer channels) for voice or data, plus one 16 Kbs D channel (data channel) for control and signalling. *Primary access* service provides a user with 23 64 Kbs B channels and one 64 Kbs D channel (for a total of 1.536 Mbs).

The following principles underlie the development of ISDN (Martin, 1988):

- ISDN must evolve from the existing telephone networks of the world
- new services that are to be offered must be compatible with the basic 64 kbs switched digital channel
- a worldwide ISDN will probably not be fully operational until the end of the 1990's, although some ISDN services are already available in some areas
- during the transition period, ISDN will rely heavily on interconnections between national ISDNs and existing public data networks
- ISDN will implement intelligence in order to perform such functions as maintenance, system control, and network management
- ISDN will use a set of layered protocols that conform to the OSI Reference Model.

ISDN will provide more economical telephone service and higher capacity facilities for data communication. As well, ISDN will make possible several services to end-users that are either not available today or available only a limited basis. Such services include:

- enhanced telephone services such as malicious call blocking, conference calls, camp on busy, and restricting outgoing calls
- information retrieval using speech recognition
- music transmission
- packet- and circuit-switched data services
- electronic mail
- alarm services
- high-speed computer communications
- teletex services

- videotex services
- high-speed facsimile services

It must be stressed that ISDN involves no new technology; all the technology required to implement ISDN already exists and is in use in telecommunications systems. ISDN is rather an exercise in standards creation and implementation, although it is severely hampered by the fact that North America has standards for digital telephony that are incompatible with those used by the rest of the world. Furthermore, there is some doubt as to whether basic ISDN service will provide sufficiently high-speed communications for the data-intensive applications which are currently in development or are expected. For example, the transfer of graphic images may be expected to require data transfer rates significantly greater than those offered by the ISDN basic access service. To help overcome this difficulty, additional data services are being standardized, including Broadband ISDN (B-ISDN), discussed below.

Conversion to ISDN will be an expensive time consuming process. A significant amount of investment into ISDN has been made by AT&T and Northern Telecom, but thus far, only a very limited number of ISDN lines are operational. In March 1990, AT&T was providing 321,000 lines of ISDN and Northern Telecom 10,000 lines (Budwey, 1990). While some observers are doubtful that world-wide ISDN will ever happen, many experts believe it is inevitable, with completion most likely by the end of the 1990's. At this time, it is impossible to predict the extent to which ISDN will actually be implemented.

Broadband ISDN

The standards for narrowband ISDN were more-or-less completed in 1988. Recent ISDN work has concentrated on developing standards and technologies for *broadband* ISDN services, which support data transfer rates higher than the ISDN primary rate. These technologies are not yet fully mature, but can be expected to have significant impacts in data communications.

Broadband ISDN is designed to support *isochronous* data transfer, in which there is a predictable interval between each data packet. X.25 and frame relay, because they are store-and-forward schemes, with variable packet lengths, have variable intervals between packets. Predictable delivery is essential for real-time transmission of digitized voice and video images.

X.25

X.25 is the name generally adopted for packet-switched communications conforming to the CCITT Recommendation X.25 and related recommendations. In X.25 data is transmitted in a series of small *packets*, each of which is carried over the network independently of other packets. X.25 communication is not point-to-point: successive packets from the same source may be sent to different targets; packets passing between the same two end points may follow different routes.

X.25 was originally designed to operate over unreliable voice-grade telephone lines, and incorporates a substantial amount of error detection and correction, together with confirmation of receipt at all intermediate destinations. The overhead involved in this means that X.25 cannot support transfer rates greater than about 56-64 Kbps. Most X.25 services provide significantly lower transfer rates, from 1200 bps to 19.2 Kbps.

X.25 is in widespread use, particularly in the provision of public data networks, and particularly outside the United States. X.25 can also be used as the data transfer and network addressing protocol on private networks of leased lines. A number of bibliographic utilities have adopted this approach to networking.

Frame Relay

Frame relay is similar to X.25 in that it is a packet-switched technology. Unlike X.25, however, it is designed on the assumption that the underlying connections are reliable digital circuits. Much of the error detection and correction and confirmation carried out by X.25 can therefore be dispensed with. The result is a data transfer protocol that can support much higher transfer rates, up to 2 Mbps.

There are now a number of commercial implementations of frame relay for use on private WANs. Typically they are used to interconnect remote LANs using a T1 leased line. This technology is also now beginning to be implemented in Public Data Networks (LAN, 1991).

Asynchronous Transfer Mode (ATM)

ATM, also referred to as *cell relay*, is a form of packet switching designed for use in the very high speed environment of broadband ISDN. Unlike X.25 and frame relay that use variable-length packets, ATM uses small fixed-length cells. An advantage of fixed-length cells is that they can be routed by specially designed hardware devices in the network, rather than the software used to route X.25 and frame relay packets. ATM will support data transfer rates from about 50 Mbps to 2.5 Gbps.

Fibre Distributed Data Interface (FDDI)

The Fibre Distributed Data Interface (FDDI) standard is well-suited for use as a high-speed platform for developing backbone local area networks (LANs). FDDI uses fibre optic media operating at 100 Mbps. This is ten times faster than the well-established Ethernet standard which uses coaxial cable operating at 10 Mbps.

In addition to providing a high channel capacity, FDDI offers the following significant benefits:

- ***low loss*** Optical fibres provide a low signal attenuation allowing greater transmission distances than metallic cable
- ***electromagnetic immunity*** This eliminates cross-talk, ground loops, and signal distortion in hostile environments
- ***security*** Fibre-optic cable cannot be tapped without the tapping being detected. External eavesdropping techniques, such as those used on metallic cable, cannot be used because fibre does not radiate electromagnetic energy

- ***low bit error rate*** Metallic cables have an error rate of one in every 1,000,000 bits, while fibre-optic cables have 1000 times fewer errors, or one error in every 1,000,000,000 bits.

FDDI has been designed for optical fibre connections. However, because fibre is more susceptible to mechanical damage than copper wire, there is considerable interest in running FDDI protocols over copper wire, especially for connection to desktop workstations. Optical fibre cabling is also now substantially more expensive than copper-based cabling. Accordingly a working group has been formed to assess the possibility of providing FDDI signalling at 100 Mbps for short distances (up to 100 meters) over both shielded and unshielded twisted-pair copper wires. If the technology proves feasible, a standard will be developed (Vereen, 1991).

FDDI-II, a new standard that will provide an even higher channel capacity, is currently under development. It is intended to provide simultaneous voice, video and data capabilities. FDDI-II uses time-division multiplexing to provide 16 separate channels, each having a capacity of 98 Mbps full duplex.

SMDS (Switched Multimegabit Digital Services)

SMDS is an emerging technology that uses dedicated telephone lines to create a wide-area network. It allows the phone numbers associated with the dedicated lines to act as a network addresses (Ratcliffe, 1991). SMDS can provide speeds of T1 or faster (Bowen, 1991), and can support a number of applications including the interconnection of LANs and the transfer of digital images (EDGE, 1991). Stanford University has experimented with the technology, using it to support applications such as the interconnection of LANs for the transfer of x-ray and magnetic resonance images.

3.3.3.2 Academic and research networks

Computer networks serving the research and educational communities, commonly referred to as *academic* or *research networks*, have proliferated during the last decade linking the computing centres of universities, colleges, and research institutions throughout the world. They began in the late Sixties both as experiments in connectivity and to promote computer resource sharing among researchers (Larsen, 1990). Subsequent development of the networks focused largely on creating an underlying communications resource that allowed a variety of tasks to be performed between remote systems and users. These services include exchanging electronic mail messages, transferring files, participating in electronic conferences, accessing databases, and logging in to distant computers. They have become such a useful tool that they have spread throughout the research community connecting hundreds of institutions. The total number of individual research networks currently numbers in the hundreds worldwide, spanning North America, the United Kingdom, Continental Europe, Australasia, Asia, and the Far East (Quarterman, 1990).

In general, research networks:

- are general purpose communications infrastructures much like a highway system is a general purpose transportation infrastructure
- were developed to provide the basis for a variety of networking tasks or end-user applications
- allow communication among any number of computers at variety of research and academic institutions
- operate in a peer-to-peer fashion, with each computer acting as an equal, or *peer* to every other (as distinct from terminal to-host networks where terminals act as simple input devices to centralized hosts)
- are independent of particular services offered
- provide access to local and remote computing and information resources
- are widely interlinked with other computer networks
- support many services such as electronic mail, remote login, and file transfer
- are exemplified by networks such as the *Internet*, JANET (Joint Academic Network), IXI, AARNet (Australian Academic Research Network), and NACSIS (Science Information Network).

Academic and research networks, because they have the ability to support many forms of communication between computers and their users, have the potential to evolve into an information infrastructure that will provide greater capabilities for the management and flow of information. This developing infrastructure will enable a larger and more diverse set of information resources to be accessed by a broader community of users, and promote increased information exchange among them. By interconnecting decentralized information centres containing a variety of forms of information, end-users will be able to search and retrieve information relevant to their work directly from the computers in their workplaces. These computers have the potential, in effect, to become doorways to a worldwide library of electronic information.

With portions of the Internet (NSFNET) now running at T3 (45 Mbps), research networks are beginning to have sufficient capacity to support document delivery, though not all subnetworks run at this speed. Major movements are underway to upgrade network infrastructures to the point where they can support EDD applications. One example is a major American initiative to develop a high-speed, high-capacity, widely interconnected research and education network that will serve academia, industry, and government. The so-called National Research and Education

Network (NREN) initiative calls on the National Science Foundation (NSF) to upgrade and expand the existing *Internet* infrastructure to establish a three gigabit/second computing network that will connect every university and major laboratory in the U.S by 1996. At speeds measured in gigabits per second, questions of sufficient capacity become irrelevant.

3.3.4 Application protocols available for document delivery

A major impediment to global networking lies in the fact that multiple network protocol suites have been specified and implemented. These suites are, on the whole, incompatible with each other. This variety of protocol suites has come about from a number of causes:

- the need for vendors of computer systems to protect their market share leading to the development of proprietary protocols
- delays inherent in the international standardization process necessitating the adoption of *ad hoc* interim protocols
- differing points of view on technical issues leading to the creation of incompatible protocols.

Major protocol suites include TCP/IP (Transmission Control Protocol/Internet Protocol), ISO-OSI, X.25, DECNET, SNA, Colored Books, and XNS (Quarterman, 1990).

The two protocol suites of particular interest in this study are TCP/IP—a mature, widely-implemented suite that is considered to be the *de facto* standard—and the ISO-OSI (Open Systems Interconnection) a suite of protocol standards that will allow the computers of different manufacturers to communicate with each other and share resources. While most institutions have endorsed the OSI Protocol Suite and have stated an intention to migrate to it, TCP/IP will be a major force for some time to come. The application protocols available for document delivery in both suites, therefore, are outlined. While subsequent chapters discussing EDD software applications focus primarily on the use of OSI application protocols, in reality, many systems will probably be required to support both OSI and TCP/IP (Lynch, 1991a).

3.3.4.1. TCP/IP

This abbreviation for Transmission Control Protocol/Internet Protocol identifies the suite of protocols initially developed for the U.S. Defense Advanced Research Projects Agency from the mid 1970's (SRI-NIC, 1985). It is today the most widely used set of standardized, vendor-independent protocols. This widespread use stems partly from the fact that TCP/IP was incorporated into a version of the UNIX operating system and thus became readily available to the academic and scientific communities who were the largest users of UNIX systems and most in need of networking services. Further, products implementing TCP/IP support communications among more hosts and different types of data links than does any other protocol suite. The types of hosts connected through TCP/IP range from Cray supercomputers to IBM PCs, and Apple

Macintoshes. TCP/IP can be carried over Ethernet, optical fibre links, DECNET, X.25 networks, satellite links, and hi-speed telephone lines. It is also the basis of the largest worldwide network, the *Internet.*

There is great similarity between the TCP/IP and OSI protocol suite in the lower four layers, namely, the Physical, Data Link, Network, and Transport layers. The two main protocols in the lower layers of TCP/IP suite are:

- ***Internet Protocol (IP)*** IP provides the equivalent of the OSI Connectionless Network Service. It moves data from end system to end system by means of connectionless packet delivery

- ***Transmission Control Protocol (TCP)*** TCP is the equivalent of the OSI Transport Layer services. It establishes a connection using the connectionless packets of the IP. It therefore provides the kind of communications that programs and users are accustomed to having.

At the Transport layer, however, the models begin to diverge. Unlike the OSI model, TCP/IP does not use a Session or Presentation layer. Instead, TCP/IP application protocols each have their own *implicit* session and presentation mechanisms, and thus interact directly with the TCP, or transport layer. In OSI, the Session or Presentation layer exist as layers separate from the applications. In the end, while the services offered by the lower layers of the two models are similar, the services needed by the application layers are very different (Rose and Cass, 1987). TCP/IP application protocols, include Simple Mail Transfer Protocol (SMTP) and File Transfer Protocol (FTP). These application protocols are outlined below.

SMTP The Simple Mail Transfer Protocol (SMTP) is the TCP/IP protocol for electronic mail. This defines an envelope to be used in delivering mail messages, together with commands and conventions for performing the delivery. The protocol requires that mail messages be in a specific format defined in a document called "RFC 822". It uses a simple mail format, with the message represented entirely as lines of text, using 7-bit ASCII encoding. The basic format uses a set of *headers*, containing data such as sender's name, recipient's name, subject, and date, and a *body* that contains the text of the message.

Because the format of the mail message is entirely text-based, transfer of binary data is not possible, nor is support available for any character set other than the basic English alphabet. Thus, the protocol is awkward to use with languages other than English, and impossible for non-Roman scripts such as Japanese, although work is underway to develop extensions to the SMTP to enable it to support the delivery of messages consisting of binary data and extended character sets. Neither is it possible to enclose binary data as all or part of a message, such as images, documents embedded with word processing code, or spreadsheet files (Stallings, 1989). Work is underway, however, to extend SMTP to support these types of messages (MacKinnon, 1991b). RFC 822 is the most widely used and widely copied of the mail format protocols and has had a profound influence on other mail protocols and systems.

File Transfer Protocol (FTP) The TCP/IP File Transfer Protocol is based on peer-to-peer interactions between a local and a remote host. As with many other TCP/IP protocols, it supports only a basic set of functions compared with its OSI counterpart:

- it supports only the transfer of files
- only complete files can be transferred
- only a few types of file structure are explicitly supported: binary files, ASCII text files, EBCDIC text files, and "paged" files.

One of the more common uses of FTP is the *anonymous FTP* convention, which allows a user to retrieve selected files from a remote system without prior authorization. This allows for rapid and informal publication of information across a network, without needing to mail potentially long documents to many users. Both text and program files are frequently distributed in this way.

3.3.4.2 Open Systems Interconnection (OSI)

OSI refers to the automated procedures, or protocols, that will allow the computers of different manufacturers to communicate with each other and share resources. OSI protocols are developed by either the International Organization for Standardization (ISO) and the International Electrotechnical Committee (IEC) or the *Comité consultatif international de télégraphie et téléphonie* (CCITT) of the International Telecommunications Union (ITU). They are issued as ISO/IEC Standards and as CCITT Recommendations, the texts of which are virtually identical. OSI uses a 7-layer architecture, known as the OSI Reference Model, outlined above in Section 3.3.1.

The specific OSI application protocols available to develop electronic document delivery systems include X.400 for message handling systems, FTAM and DTAM for file transfer, the ISO ILL Protocol for ILL messaging, the X.500 Directory standard, and the SR protocol for information retrieval. In addition, EDI standards are available to support the exchange of business records generated during a document transaction.

3.3.4.2.1 X.400 Message Handling Systems

Message handling systems based on the CCITT X.400 application protocol manage the delivery of mail by providing an addressable envelope into which users, machine or human, can insert messages that are then forwarded by the system. Of special significance for electronic document delivery is the fact that these systems allow a wide variety of message types to be enclosed within the envelope (Swain and Tallim, 1990). The forms most germane to this discussion are bit-mapped images and documents structured with ODA or SGML. The ability to accommodate these types of document formats makes message handling systems particularly useful for building applications for document delivery.

X.400 and facsimile

Typically, fax images are exchanged through the use of fax machines permanently connected to dedicated telephone lines. In message handling systems, the fax image can be contained within the envelope thereby allowing its transmission over an X.400 network instead of a dedicated telephone line.

Since X.400 is a store-and-forward service, a key benefit of such transmission is that the network will wait until the recipient is available to receive the message before delivering the message. For fax transmission, this solves the problem of having to redial a fax machine when a busy signal is received. There is, however, an inherent limitation on the size of messages that can be sent due to the X.400 content length limitation of two gigabytes as well as the physical storage limitations of X.400 message transfer agents.

Further benefits of using X.400 for fax image transmission include more specific addressing capabilities, delivery notification, better security, and provision of additional valuable information. The more specific addressing capabilities allow fax messages to be sent directly to a user's workstation rather than to an office or departmental fax machine. Delivery or non-delivery notification provides the sender with an acknowledgement that a sent message was received. Better security is provided by allowing the sender to control who may read the message. Finally, additional valuable information is provided such as the time the message was sent, the time it was received, and, if the message was sent to multiple users, who received the message.

X.400 and ODA, X.400 and SGML

The ability to accommodate ODA and SGML documents within the X.400 envelope allows documents with complex structures, and those containing both text and graphics, to be transferred over a network and interpreted by the recipient. Most X.400 implementations (based on the 1984 version) currently support transmission of simple text (IA5 international alphabet). The 1988 version of X.400 allows any body part type (including ODA and SGML) to be conveyed.

Product availability

Many X.400 compliant mail systems and X.400 gateways to proprietary mail systems are currently available for most of the major computer environments including UNIX, MS-DOS, Macintosh and DEC VAX/VMS. The major computer manufacturers with environments that do not have X.400 support plan to provide it in the future.

3.3.4.2.2 File Transfer (FTAM, DFR, DTAM)

The File Transfer, Access and Management (FTAM) protocol, the Document Filing and Retrieval (DFR) protocol and the Document Transfer, Access and Manipulation (DTAM) protocol can be used for the transfer of documents in an electronic document delivery environment. FTAM, DFR and DTAM are all methods of transferring documents from computer to computer which involve connecting to a remote host and requesting a particular file to be sent or received. These protocols are outlined below.

FTAM FTAM, ISO 8571, can be used for the reliable transfer of large documents between computer systems. It is usable for small documents as well, but the considerable amount of dialogue to prepare for the transfer (connection establishment, file selection, file open, read or write) makes FTAM less attractive for the transfer of small documents. The functions of FTAM are grouped into three service classes:

- file transfer class is intended for the transfer of entire files
- file access class is intended for the manipulation of parts of files, e.g., individual records
- file management class is intended for operations on files as a whole.

DTAM DTAM, CCITT Recommendation T.431, is intended to support bulk transfer of Group 4 facsimile and mixed-mode Teletex documents as well as interactive manipulation of remote documents that are structured according to the ODA standard. To support manipulation of remote documents, operations parallel to the existing ODA logical and layout structures are being defined that are intended to support activities such as remote document editing, remote data entry using prompts, and automatic generation of tables of contents, indexes, and dictionaries. There is no OSI equivalent of DTAM, although ISO DFR (see below) may be extended to be compatible with DTAM (MacKinnon, 1991a).

DFR Document Filing and Retrieval is an ISO standard to support filing operations on documents, largely in a distributed office context. The services offered are similar to those of FTAM or the proprietary Network File System (NFS), widely implemented in LANs, although documents transcend the model of a computer file and are hierarchically organized. The development of DFR has been largely undertaken in Europe.

A limitation of these methods of transfer for document delivery is that a direct connection between machines is necessary for the file transfer process; unlike store-and-forward delivery, documents cannot be sent to the user for acceptance at a later unspecified time. This is a particular problem with the transfer of image data which can involve very large files and transfer times.

Many FTAM products and services are available for most of the major computer environments including UNIX, MS-DOS, Macintosh, IBM and DEC. Implementors have adopted a phased approach, and are implementing only a subset of the full FTAM functionality. In particular, the early phases support only transfer of full files and recognize only a limited number of file types. The major computer manufacturers with environments that do not have FTAM support plan to provide it in the future. Products supporting the DFR protocol are in development but are not widely available yet. Work on DTAM standards is at an early stage; it is expected that most of the standards development work will be complete by 1992.

3.3.4.2.3 ILL Protocol

Interlibrary Loan (ILL) is a resource sharing mechanism for exchanging books and periodicals among bibliographic institutions. The ILL protocol is a computer communications standard based upon the OSI Reference Model for exchanging ILL messages such as borrow requests, indications of receipt and return of borrowed items, renewal requests, notifications of lost items, and cancellation of requests.

The fundamental benefit of the ILL protocol is that it allows ILL systems to communicate with each other regardless of the design of the ILL software, the hardware used to run the system, or the communications services selected to transmit the ILL protocol messages (Turner, 1990). A second benefit is that the standardized structure and content of the protocol establishes a foundation upon which to build a variety of compatible ILL systems and services. A third benefit is the improvement of transaction control and tracking. Furthermore, the transaction messages can be used to generate statistics on ILL message traffic, service provision and other management concerns.

When used in conjunction with protocols that address aspects of ILL other than transaction control and messaging, the ILL protocol provides even more benefit. For example, when used with ANSI Z39.50 or the ISO Search and Retrieve (SR) protocol (see Section 3.3.4.2.6), citation or location information retrieved using these protocols can be incorporated into ILL messages such as borrow request and answer messages.

The ILL protocol was approved in April, 1991, as an International Standard by the International Standards Organization (ISO).

3.3.4.2.4 Electronic Data Interchange (EDI)

Electronic Data Interchange (EDI) is the electronic exchange of business documents such as purchase orders, invoices, shipping notices and the like, that adhere to a set of standards. The emphasis is on the word "standards". Although companies have been trading electronically in one form or another for over fifteen years, an electronic transaction is only EDI if the data is structured according to a standard, non-proprietary format. EDI standards specify the structure and syntax of the data to be exchanged, but they do not specify the mechanisms for transporting the data.

Industry has realized several benefits through the use of EDI (Software Kinetics, 1988). Some of these benefits are:

- ***reduced clerical costs in data entry*** (i.e no re-keying of information)
- ***reduced overhead and administrative costs*** including those for paper and supply inventories, stuffing, and filing

- ***improved data timeliness*** leading to reduced inventory stock, and overall better inventory management
- ***reduced errors*** as fewer people rehandle the information.

While benefits derived from reduced paper handling and smaller inventories may justify the deployment of EDI within larger companies, small and medium companies often base their rationale for EDI on the competitive edge it can bring by improving customer service. Factors contributing to improved customer service include improved speed of access and accuracy of information. In certain markets where customer service, as opposed to price or product, is the main basis for competition, EDI can be an essential component of an organization's corporate strategy.

Within North America there are approximately 15 different EDI standards in use. Some of the more widely used standards are the following:

- Transportation Data Coordinating Committee (TDCC) RAIL, MOTOR, OCEAN and AIR standards in the transportation industry;
- Uniform Code Standard (UCS) in the retail and grocery industry;
- Warehouse Information Network Standards (WINS) within the warehouse industry; and,
- X.12 developed by the American National Standards Institute (ANSI) as a generic standard for cross-industry use and has been adopted by the electrical, chemical and other industries.

Internationally, the United Nations Joint Electronic Data Interchange Committee has developed a standard for international trade, known as EDIFACT (Electronic Data Interchange For Administration, Commerce and Transport).

These standards differ in the range of data elements supported and the order in which data elements are conveyed within a transaction set. Therefore, when trading partners agree to use EDI standards, the question arises as to which "standard" to use. A general consensus on the use of a single international EDI standard in the long term, the EDIFACT standard, is emerging within industry and government. This standard will allow companies and government to communicate worldwide through a single set of rules. The ANSI X.12 standard is emerging as an interim standard to be adopted in the short term.

Transmission of graphical information and X.400

As the use of EDI is being adopted by a broader range of industries, (e.g., aerospace, electronics firms), the need to send detailed engineering specifications, including diagrams and computer-aided design (CAD) as attachments to the business document is emerging. EDI standards do not currently support the transmission of this information.

A method that provides this capability has been addressed by CCITT Study Group VII on EDI and X.400 (CCITT Study Group VII, 1989). The group has decided to deal with EDI in X.400 as a cooperating User Agent service, equivalent to, but separate from, the Interpersonal Message (IPM) service, and carried by the Message Transfer Service. An EDI Messaging System (EDIMS) would be designed to be equivalent to the Interpersonal Messaging System (IPMS) now included in the X.400 Recommendations. CCITT Recommendation X.435 provides a technical definition of the EDIMS including the structure of EDIMS messages where an EDI Interchange occupies one body part of an EDIMS message. Additional body parts carry information supplementing the Interchange, for example engineering drawings or specifications. With this approach, the flexible binary structures of X.400 provide advantages over the traditional EDI encoding methods. In particular, multiple messaging standards can be used, even to the extent of mixing standards in a single message. Thus X12 and EDIFACT messages could be sent in a single transmission.

3.3.4.2.5 X.500 Directory

The CCITT X.500/ISO 9594 Directory standard describes services and protocols that will provide global access to a repository of network service information. It defines one global directory that is logically centralized, but physically distributed across numerous interconnected nodes.

Basically, the Directory acts like a phone book for computer networks (Retix, 1990). Users and applications can use the Directory to look up addresses of other users and applications in order to establish communications. Ultimately, the Directory will provide comprehensive information regarding network users, systems and applications, and will likely be extended to provide more general information services.

The Directory standard is an OSI application layer protocol. It can be integrated with other application protocols such as Interlibrary Loan (ILL), File Transfer, Access and Management (FTAM), and Message Handling System (X.400) to enhance the usefulness of the protocols (Planka, 1990). For example, an ILL application could query the Directory for information about libraries regarding the strengths of their collections and the types of materials offered. An FTAM application could query the Directory for the document types supported by a particular file store. An X.400 application could query the Directory for addresses of applications to which it wishes to send messages.

Of particular interest to bibliographic institutions is the capability to store and access information on library collection policies and practices, and even indexes to authors, subjects, and titles in various library collections.

X.500 products and services are available for UNIX and MS-DOS environments. The major computer manufacturers with environments that do not have X.500 support plan to provide it in the future. Several projects are underway listed in Section 5.4.

3.3.4.2.6 Z39.50/SR

Z39.50 is an OSI application layer protocol for information retrieval (IR). It is an American National Standard adopted in 1988. The International Standards Organization analog of Z39.50 is ISO 10162/10163 called Search and Retrieve (SR). The two parts of ISO SR are the service specification and the protocol specification. Functionally, ISO 10162/10163 can be viewed as a compatible subset of Version 2 of Z39.50 (cf. McCallum, 1990).

Z39.50 allows an application on one computer to query the database on another computer. It specifies a general framework for transmitting and managing database queries and results. The framework is quite independent of the semantics of the information being retrieved. Z39.50 also specifies a syntax for formulating queries.

The protocol interactions of Z39.50 are expressed in terms of client (user) requests and server (database) responses. The basic functions specified by Z39.50 are the following:

- ***Initialize*** This function establishes the IR session. The client issues an *initialize* request and the server responds with an *initialize* response.

- ***Search*** This function allows the client to query the database for specific information. The client issues a *search* request and the server responds with a *search* response. Only one request can be outstanding at any given time. If the query is successful, a result set is created on the server.

- ***Present*** This function causes the result set to be transferred back to the client. The client issues a *present* request and the server responds with a *present* response. Only one request can be outstanding at any given time. Several requests may be required to transfer all of the result set records back to the client.

- ***Release*** This function ends the IR session. The client issues a *release* request and the server responds with a *release* response.

- ***Delete***. This function disposes of result sets held on the server during a session. The client issues a *delete* request and the server responds with a *delete* response.

In addition to the above basic functions, the server may interrupt a client request with an *access control* or *resource control* request. These place the current operation on hold until the client responds. Access control is a security measure that permits the server to ask the client for authentication. As an example of resource control, the server could notify a client that a query will take a long time or produce a large result and request confirmation to proceed.

The Z39.50 Implementors Group was formed in March 1990 to agree on a number of options in underlying protocols and to resolve issues arising in the protocol itself (Hinnebusch, 1990). It consists of a number of institutions and vendors interested in developing a Z39.50 support capability. The National Information Standards Organization (NISO) has designated the Library of Congress as the Maintenance Agency for Z39.50 (Peters, 1990). It will organize experiences with and recommendations concerning the implementation and evolution of the Z39.50 standard.

Interest in Z39.50 has been growing rapidly and a number of implementations are expected to become operation in the first quarter of 1992. Implementors include large academic libraries, commercial library system vendors, and also general computer manufacturers (Sun, Apple, Next) who intend to use the protocol to support "Wide Area Information Systems". The maintenance agency has established a list of implementors and is developing an implementation profile and an implementor's conformance statement.

3.3.4.3 OSI and TCP/IP coexistence and transition

This section deals almost exclusively with the interrelationship of TCP/IP and OSI. The focus on these two suites is due to the fact that, of the three most widely-used protocol suites (SNA, DECNET and TCP/IP), TCP/IP alone is non-proprietary and therefore issues surrounding it are more readily debated in public forums. Nevertheless, the issues of co-existence with and transition to OSI are not dissimilar in principle for all the major protocol suites, although the implementation details obviously will vary.

Note that co-existence is not the same as transition: *transition* implies a community consisting of networks that currently contain only one protocol suite (i.e., TCP/IP) that wishes ultimately to contain only another protocol suite (i.e., OSI). *Coexistence*, on the other hand, implies two communities, each containing a different protocol suite, which wish to interoperate with each other. The approach taken here is that a strategy that allows co-existence will eventually lead to transition as one of the protocol suites "withers away" for lack of support, or as the product of the union between OSI and TCP/IP reaches maturity.

Co-existence can be accomplished in several ways: the dual stack approach, the protocol gateway approach, and the service bridge approach. Of these, the dual stack approach does not offer interoperability, only the capacity to run the two separate suites over the same physical connections. The other approaches do offer some degree of interoperability.

- ***Dual stack*** In the dual stack approach, some, or all, computer systems in a network implement both protocol suites, at least as far as the data link level where the protocols become identical. The most effective approach requires both suites to be present in all nodes of the network (*dual-stack* nodes). In practice, however, many nodes of the network will contain only one protocol suite (*uni-stack* nodes). This heterogeneity can lead to difficulties when different stack types attempt to communicate. For example, communication between two dual-stack nodes or between dual-stack/uni-stack pairs can take place because the presence of a protocol suite common to them both is guaranteed. Difficulties can arise, however, when the user on a dual-stack system does not know which protocol suite to use when communicating with any particular uni-stack system ("Do I use FTAM or FTP?"). Further, the user may not know in the first instance that the system with

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which he/she is communicating only supports one stack. A more serious problem results when two uni-stack nodes try to communicate since one uni-stack node will be able to communicate with another uni-stack node only if the protocol suite they support is the same.

- ***Protocol gateway*** In this approach, a number of dual-stack systems are present in the network that can translate between one protocol suite and the other; the dual-stack node acts as a *gateway* between the two protocol suites. This approach is at present widely implemented for electronic mail applications. It could also be implemented for other network applications that are functionally similar in the two protocol suites.

  There are, however, a number of problems involved in using gateways to interconnect incompatible networks. The processing required at the gateway can affect performance severely. In addition, if there are only a few gateways available, there is a substantial risk of bottlenecks developing. The services offered by the two protocols will inevitably be different, and a mapping between the two will necessarily result in a loss of information. This loss, at least, can result in the annoyance of a user and, at worst, to catastrophic situations, such as a routing loop. This situation is worsened when two or more gateways need to be traversed. Gateways should therefore be seen primarily as short-term solutions to achieve connectivity, rather than long-term means of achieving co-existence.

- ***Service bridge*** The service bridge approach involves devising mechanisms to allow the services of one protocol suite to be available via the other. In this case, to allow TCP/IP networks to support OSI upper layer protocols, and thus OSI applications.

TCP/IP is by far the most commonly used protocol suite for interconnecting computer networks in the academic and research community. It is now so well accepted as a proven, stable, and mature protocol suite that it will undoubtedly remain viable for many years to come. Sales of technology based on the TCP/IP protocol suite continue to grow, despite the public commitments of national governments and major vendors to OSI. This approach is particularly true of Europe, even though Europe has been a strong supporter of OSI in the international community. Some experts in the area agree that ultimately networking based on OSI application standards will supersede TCP/IP (DiDio 1989; Fisher 1989; Rose 1989). This will take place because of government regulation, through Government Open Systems Interconnection Profiles (GOSIP), and because of the greater functionality offered by the OSI applications, such as X.400 and FTAM.

Nevertheless, TCP/IP and OSI will co-exist for some years to come, and the transition from one to the other will be gradual. For economic reasons, this co-existence will be on the same physical networks: the same computers, circuits, routers, and other paraphernalia that make up a network. Given this fact, the first requirement must be to ensure that communication using one protocol suite does not interfere with the other. This requirement has already been met, at least at the lowest protocol layers; there are no interoperability issues at the physical layer as OSI and TCP/IP packets are identical. At the data link layer, OSI and TCP/IP packets can be simply and readily distinguished enabling them to be passed to the correct network layer implementation. This allows TCP/IP and OSI to co-exist on LANs and on X.25 networks. The problems begin at the network layer, where a number of important areas have not yet been standardized for OSI, although work is in progress.

The following sections describe some of the ways in which co-existence and gradual transition might take place.

3.3.4.3.1 OSI over TCP/IP

The opportunities for running OSI over TCP/IP stem from the fact that these protocol suites, both based on layered models, are very similar at their lowest layers, from the Physical layer through to the Transport layer. In fact, TCP/IP now generally uses OSI protocols at the Physical layer and the Data Link layer (X.21 and HDLC, respectively). Because of the similarity at lower levels, it has been suggested that one mechanism for transition would be to run OSI upper layers on top of TCP. This would have the effect of providing OSI transport layer services as a TCP/IP application protocol. A single network infrastructure would therefore be able to support both TCP/IP and OSI applications. This approach has been formalized in a TCP/IP document (RFC 1006) and is implemented in the ISODE application development environment for UNIX systems.

A similar approach uses a joint network layer protocol to route OSI transport layer data units as well as TCP packets over an underlying data link service. This dual OSI-TCP IS-IS router has been specified in RFC 1195. Again, it allows co-existence of TCP/IP and OSI environments, but does not offer application level interoperation; it merely allows OSI applications to interoperate with other OSI applications over a TCP/IP network. TCP/IP applications and OSI applications would remain entirely separate unless specific application gateways were built (Callon, Hagens, and Nitzan, 1990).

3.3.4.3.2 OSI gateways for existing systems

One important reason for the slow adoption of OSI, particularly among vendors of library systems, is that implementation of OSI application level protocols would require major changes in their software, often at the level of basic system design. Bibliographic applications are very complex in comparison with other business applications, and vendors are understandably reluctant to invest large sums on making radical changes to systems that currently both work well and have a high degree of acceptance.

A central problem is that, while functions are highly modular in present-day systems and data is highly integrated, both the functions and the data are often tied directly to a particular user interface. Two examples of this dependency are: 1) when the formulation of a database search cannot be separated from the screen display used to input the search terms; and 2) when data is stored in a manner that minimizes processing when it is output to the screen. In both cases, the function design and data structures are inextricably intertwined with the user interface. To convert the application from such a monolithic, centralized model to the distributed client-server model, typically required by OSI, would require that the whole design of the system be changed.

One means to overcome the problem of system redesign in the short to medium term is to leave the system unchanged and build a *gateway* to sit between the system and the OSI application. This gateway would receive OSI messages, process them internally to generate the appropriate commands for the non-OSI system, receive its replies, process them and generate OSI messages. There are, however, a number of difficulties with this approach. First of all, by adding a possibly very complex processing layer, response times may be significantly worsened and/or additional processing power may be required. A second problem is that, while it is possible to design gateways that use existing bibliographic applications as servers, it is much more difficult to implement a gateway that allows an existing system to act as a client (Callon, Hagens, and Nitzan, 1990).

3.4 Workstation technologies

Over the past decade, computer system architectures have been moving toward distributed processing and away from the more traditional centralized processing. Advancements in workstation technology have been key in allowing this evolution to occur. Today, workstations with powerful processors, lots of memory, high storage capacities and high-resolution colour graphics displays are commonplace. Accompanying improvements in workstation technology have been dramatic advancements in user interface technology. Graphical user interfaces (GUIs), which use the screen like a bit-mapped graphics image to display windows, icons, and pop-up menus, are becoming popular among computer users.

This section discusses workstation evolution in general and graphical user interfaces, in particular.

3.4.1 Workstation evolution

A workstation is a computer system that resides at the user's desk and contains its own processor, local memory, graphics display and optionally, hard disk. Workstations are often connected to a local area network (LAN) as part of a distributed computer system and incorporate a multitasking operating system and a graphical user interface. In electronic document delivery, workstations are used to view, manipulate, and process digitized images. *Workstation*, in this context, is used as a general term to describe a user's computer system. However, workstations can be further classified into *personal computers (PCs)*, *personal workstations*, and *engineering workstations*, (or just *workstations* as they will be referred to herein).

One constant in the computer industry is that the price/performance ratio keeps going down (Baran, 1989). This trend has caused the distinction between low-end workstations and high-end personal computers (PCs) to be blurred. This blurred class of computer has been termed *personal* *workstation.* The personal workstation can be defined as having the following features (Baran, 1989):

- 32-bit processor
- at least four megabytes of memory
- 1024- by 800-pixel screen resolution or better
- 4 or eight bit planes of colour
- optional hard disc storage
- ethernet and Unix capabilities
- floating-point co-processor

Personal workstations, for their level of functionality and their relatively low price, are probably the most applicable class of computer for use in the electronic document delivery environment.

The Personal Workstation

To show where contemporary personal workstations fit within the PC/workstation market, some history is provided. Historically, workstations have been one step ahead of PCs in hardware and software technologies. Workstations started out with more a powerful processor (16-bit as opposed to 8-bit), more memory and storage, and more advanced graphics, and offered networking capabilities first. Workstations ran Unix, which provided multitasking and large memory management capabilities, well before such features were available on PCs.

In software, PCs started out with games, simple file management and text editors while workstation software migrated from professional-level applications. Structural analysis, CAD, graphics design, database management, and page layout were the core applications on workstations.

Today, a PC can be configured to meet and exceed the performance of the early workstations. Unix and other multitasking operating systems can be run on a PC. Professional-level spreadsheet, database and word processing programs are available for the PC that are functionally superior to those available on workstations for hundreds or even thousands of dollars less. Further bridging the gap between workstations and PCs is that many workstations offer a method of running MS-DOS (the IBM PC operating system) as a task in the Unix environment.

Workstations provide greater performance and features than personal workstations, but at a greater cost.

State-of-the-art workstation technology

Several significant developments have occurred over the past year in the "personal workstation/workstation" market. IBM introduced a new line of powerful RISC workstations and servers, and Sun Microsystems, NeXT Computer and Hewlett-Packard introduced workstations edging closer to the PC market (Rosenblatt, 1991). Given the pace of change in the computer industry, however, these specific developments may be out of date very soon. Nevertheless, the following developments provide examples of the trends in workstation technology:

- In February 1990, IBM introduced a new family of powerful Unix-based reduced-instruction-set computer (RISC) workstations and servers. Within this family, IBM claims the most powerful desktop workstation, the Powerstation 320, capable of 27.5 million instructions per second (MIPS). This family includes IBM's second-generation RISC technology that separates the processor into three independent functional units—branch, fixed-point and floating-point—which permits concurrent execution of multiple instructions. The Powerstation 730, a "supergraphics" workstation, matches speeds of 34.5 MIPS and 10.9 million floating-point operations per second (MFLOPS) with graphics performance of almost one million 3D vector transformations per second.

- The diskless SparcStation SLC has a performance of 2.5 MIPS and 1.2 MFLOPS. It has a 17-inch monochrome display of 1152 by 900 pixels. A RISC workstation, the SparcStation IPC, has a performance of 15.8 MIPS, and includes a 207 megabyte hard disk drive and a DOS-compatible 3.5 inch floppy drive.

- NeXT Computer's NeXTstation computer features 15 MIPS performance, a 68040 microprocessor and a graphical user interface.

- Hewlett-Packard's Model 400dl entry level-desktop computer has a performance of 12 MIPS and is upgradable to 20 MIPS by substituting the base 68030 processor with a 68040. Other new HP computers reach performances of 26 MIPS.

Other major computer manufacturers are making similar introductions in the "personal workstation/workstation" market.

3.4.2 Graphical User Interfaces, X Windows And Motif

Graphical User Interfaces

Within a graphical user interface (GUIs), the computer screen appears as a desktop, displaying objects such as windows and icons that can be moved around and shuffled. The screen is treated like a bit-mapped graphics image with "soft" fonts and a mouse-driven pointer that can be moved around by single pixel increments (Pountain, 1989). Windows appear on the screen that can obscure one another, be moved and resized, and contain pointer-activated controls for scrolling and zooming. Special kinds of windows called menus and dialogue boxes present choices from which to select by pointing rather than typing commands.

Some of the more common personal computer GUIs are the Apple Macintosh interface, Microsoft Windows for IBM PC-compatibles, and Digital Research's GEM which is best known as the GUI of Xerox's Ventura Publisher. However, two limitations that are common to all of these interfaces are that they operate only on single-user systems and that they are closely tied to the target hardware.

On workstation-level computers, these limitations have been addressed. Windowing systems have been developed that are network-transparent and device independent. Such systems allow a program on a network workstation to create windows on the screen of another workstation, even if it is made by a different manufacturer.

It appears as though the workstation world is settling on the X Windows System developed at the Massachusetts Institute of Technology (MIT, Cambridge, MA) as the windowing standard (Pountain, 1989) with Motif as the accompanying GUI based upon X Windows.

The X Windows System and Motif

X Windows is a distributed, network-transparent, device independent, multitasking windowing and graphics system. Multiple applications can be displayed on the same screen, each within its own window. X Windows also allows a single application to use many windows. Windows can overlap or be hidden. The system also supports soft fonts and two-dimensional graphics drawing (Vereen, 1991).

X Windows achieves its distributed, network-transparent and device independent characteristics by splitting its functionality into two parts using the client/server model. The client is an application program that makes requests of the server program to draw windows, text and other objects. The server is a program running on each workstation that draws the requested objects on the display. Each workstation has its own server that contains hardware dependent device drivers for that workstation.

The client sends packets of instructions to the server that conform to the X Protocol, which is a high-level graphics-description language. The client and the server may be resident on the same workstation, when a single user is executing a program locally; or they may reside on different computers communicating with one another over a network.

X Windows provides the mechanism for drawing windows and sending graphics over a network, however, it does not define the user interface that runs on top of it. The user interface specifies what windows and icons look like, how the user interacts with them, and so on. A number of graphical user interfaces for X-Windows are available. The two most important are Open Look from Sun Microsystems and AT&T and Motif (Burgard, 1991). Motif, for example, is a user interface based upon X Windows that is emerging as a GUI standard, particularly for Unix systems. Motif was developed by the Open Software Foundation, which includes such vendors as IBM, HP, DEC and more than 40 others. It is designed to be totally device independent. It is currently available for a variety of Unix-based platforms.

Some hardware and software vendors are beginning to support the use of PostScript as a tool for creating VDU displays. The first vendor to do so was Next, Inc. on its Next computer. Since then, several have used the Display PostScript developed for use on the Next to control screen displays, particularly in conjunction with X-Windows. This approach has the advantage that, in theory at least, screen and hard copy displays should be virtually identical in appearance.

3.5 Hardcopy production

Hardcopies of documents will continue to be required in the electronic document delivery environment. Hardcopies have many desirable characteristics: they are portable, they are easily marked and annotated, and no special tools are required (such as a laptop computer) to read a paper document.

The following subsections discuss laser printer technology.

3.5.1 Laser printers

High quality, printing speed, low noise levels, affordability and ease of use make laser printers ideal for many library printing applications (Kelly, 1988). Laser printers, like photocopiers, use single sheets of bond paper in either the 8.5-by-11 inch or 8.5-by-14 inch sizes. If desired, preprinted paper stock can be used. Although there are many laser printers available, only three are highlighted below. These are HP LaserJet II compatible and PostScript printers, highlighted primarily because of their prominence in the industry, and Xerox's DocuTech Publishing System, highlighted because of it provides an example of high-end, integrated printer/publishing systems that may be of importance to electronic document delivery in the coming decades. A brief discussion of colour laser printing is also provided.

HP LaserJet II Compatibles
Hewlett-Packard (HP) LaserJet II compatible printers offer fast text printing and basic graphics capabilities. Furthermore, most commercial software packages support LaserJet II output.

HP no longer sells the LaserJet II replacing it with the LaserJet III, which offers enhanced PostScript-like features. A major drawback of the LaserJet III, however, is that most applications do not yet utilize its enhanced features. Therefore, a less expensive LaserJet II compatible printer may be adequate.

The following is a summary of the major features taken from a recent guide to 31 LaserJet II compatibles (cf. Tynan and Smith, 1990):

- ***Price*** Prices range from $1399 US to $4695 US. Estimated cost per page ranges from two cents per page to 4.12 cents per page.

- ***Speed*** Speeds range from six pages per minute to 12 pages per minute.

- ***Durability*** Durability ranges from a monthly duty cycle of 3000 pages to 25,000 pages.

- ***Fonts*** Some printers come with as many as 79 resident typefaces. Compatibility with HP and third-party downloadable soft fonts is also available.

- ***Expandability*** Most printers come with 512 KB or 1 MB of standard RAM. Some offer expandability up to 5 MB.

- ***Paper Handling*** Some printers offer a paper capacity of up to 1000 sheets. Multiple trays, face-down output, and duplex printing options, as well as the ability to handle letter- and legal-sized paper, envelopes, labels and transparencies are available.

Postscript printers

PostScript printers provide a broad assortment of scalable typefaces and superior graphics capabilities. They use the widely adopted PostScript standard supported by almost every application. Some also emulate HP LaserJet printers.

The following is a summary of the major features taken from a recent review of six PostScript printers (cf. Smith and Tynan, 1990):

- ***Speed*** For text printing, speeds range from eight to 15 pages per minute. For intensive font scaling and graphics composition, speeds vary considerably. The processor speed is the main factor.

- ***Output Quality*** PostScript printers typically provide a resolution of 300 by 300 dots per inch (dpi). Resolutions of up to 800 by 400 dpi are available.

- ***Font Options*** For downloading fonts, RAM options ranging from 2 MB to 12 MB are available. Font cartridges and font cards are also available. For even greater font storage, some printers interface to hard disks.

- ***Paper Handling*** 200- to 500-sheet paper cassettes are typical. 1000-page sheet feeders are available. Dual cassettes, and the ability to handle letter- and legal-sized paper, envelopes, labels and transparencies are available. Durability ranges from a monthly duty cycle of 5000 pages to 25,000 pages.

- ***Price*** The six printers reviewed range from $4293 US to $6572 US. Estimated cost per page ranges from 2.64 cents per page to 3.7 cents per page.

Xerox DocuTech Publishing System

For very intensive document delivery operations, such as an academic library or campus document delivery service, standard laser printer technology may not be sufficiently fast or robust. For such intensive use, new types of integrated printer/publishing systems may be more appropriate. One example is Xerox's recently introduced DocuTech Publishing Series, an integrated printer server that combines image scanning and processing with high-speed printing (Moad, 1991). The system provides a number of advanced features in one integrated system:

- 135 page-per-minute, 600 dpi laser printing
- document scanning and processing
- automated booklet-making and document binding
- connectivity to local area networks
- compatibility with leading desktop publishing packages and page descriptions languages (Moad, 1991).

The system allows in-house publishing of documents of presentation quality. At a price of $220,000, however, such high-end systems may only be appropriate for large-scale document delivery services.

Colour laser printers

At present, few colour laser printers are available and those that are available are expensive. Typically, they are offshoots of electrophotographic copiers.

The major technical issue facing colour laser printer developers is to find a method to put all four colours on paper in a single pass. In the laser printing process, a photoconductive surface is first imaged by laser light (and hence charged), then toner is attracted and transferred to the photoconductor. Next, the toner is transferred from the photoconductor to the page. Finally, the toner is fixed to the page through a mechanism employing heat and pressure.

Colour laser printing, in contrast, generally requires a multiple-pass process, one for each of cyan, magenta, yellow and black. The problem is that the four toners are not fixed to the page until the entire image has been transferred. Because the four toner powders must remain unfixed throughout the process, they can fall off the image and allow contamination among the four different toners (Emmett, 1991). Another problem facing colour laser printer technology is that much cheaper colour ink-jet and colour thermal transfer printers are available. Laser printers do, however, offer distinct advantages over these other printer technologies including higher quality images at faster speeds as well as plain paper printing.

4. ELECTRONIC DOCUMENT DELIVERY APPLICATIONS

The standards and technologies outlined in the previous chapter form a constellation that can be used to automate the document delivery process. While Chapter 3 describes each convergent technology in a generally independent fashion, the present chapter fits the technologies together to form applications that will support electronic document delivery. The shift from current document delivery methods to more advanced applications, will not appear in a revolutionary manner, but will most likely evolve incrementally out of existing library systems (Lynch, 1990). These systems include those in current use for information access and document supply, such as public access catalogues, online journal indexing and abstracting databases, email systems, facsimile machines, imaging systems, and various network services.

To reflect this evolution, this chapter is broken into two major sections: *current and transition phase alternatives* and *advanced EDD applications.* The first section incorporates a number of presently available technologies into techniques for the rapid transmission of documents between ILL departments. The second section uses state-of-the-art and emerging technologies and OSI standards to construct a more sophisticated EDD software application that functions within a networked environment, allowing users to select, request, and obtain electronic documents directly from their workstations.

It is important to stress that it is impossible to predict the exact configuration that may appear at the focal point of these converging technologies. In fact, it is somewhat reckless to do so given the often chaotic nature of the evolution of information technology. The applications outlined below, therefore, are presented as *examples* of possible configurations for the purpose of illustrating how the standards and technologies can be used in a integrated manner, rather than representing the only possible, or optimal, configurations.

4.1 Current and transition phase alternatives

The immediate goal will be to automate those functions within the document delivery process that are still based on manual methods, as discussed in Chapter 2. Most notably, these functions are *document retrieval* and *document transfer.* Because documents are currently stored predominantly in paper form, initial strategies will involve "on-the-fly" document delivery—the digitization and transmission of documents on demand. For this purpose, facsimile document delivery will continue to be, for the present, part of a library's document delivery system. Further on, document imaging systems, such as RLG's Ariel, may gain more widespread use for on-the-fly transmission, as well as for preparing image databases for automated retrieval of documents.

In addition, while requests for documents in the near future will most likely continue to arrive through proprietary ILL subsystems and through electronic mail, these methods may eventually be replaced, at least for libraries, by applications based on the ISO ILL Protocol. The following sections examine some facsimile and document imaging system configurations, as well as some possible early implementations of the ILL protocol.

4.1.1 Facsimile document delivery

Group 3 fax over the voice-grade public switched telephone network (PSTN) will probably continue to be the predominant fax standard for the next few years. It is expected that Group 4 fax will become more prevalent as lower cost Group 4 products become available and as digital network facilities required to support Group 4 fax transmission become more widespread.

Figure 4-1 presents three Group 3 fax alternative configurations based upon currently available technologies: stand-alone Group 3 fax machines, and personal computer (PC) fax boards. Please refer to this diagram during the following discussion of alternative fax configurations.

Library A contains a *stand-alone Group 3 fax machine*, a configuration that will be most familiar to librarians. With such a machine, paper documents can be sent and received using a single self-contained component. This standard fax-to-fax connection via telephone lines is a configuration that is currently in wide use in libraries for document delivery.

Library B contains a configuration centred around a *Group 3 fax board* within a PC. The configuration also contains an image scanner and a laser printer as well as the necessary PC software required to interface all the components to one another. Such a configuration offers the following advantages over a stand-alone fax machine:

- incoming fax transmissions can be stored electronically as files on the PC rather than on paper
- incoming fax transmissions can be viewed on the PC's screen without the requirement to generate hardcopies to read them
- if desired, hardcopies of fax transmissions can be printed on the laser printer. The hardcopies are printed on plain paper rather than on the thermal paper used in most Group 3 fax machines
- electronic documents created by word processing, graphics, spreadsheet or other application programs are used as the source for outgoing fax transmissions, rather than paper.

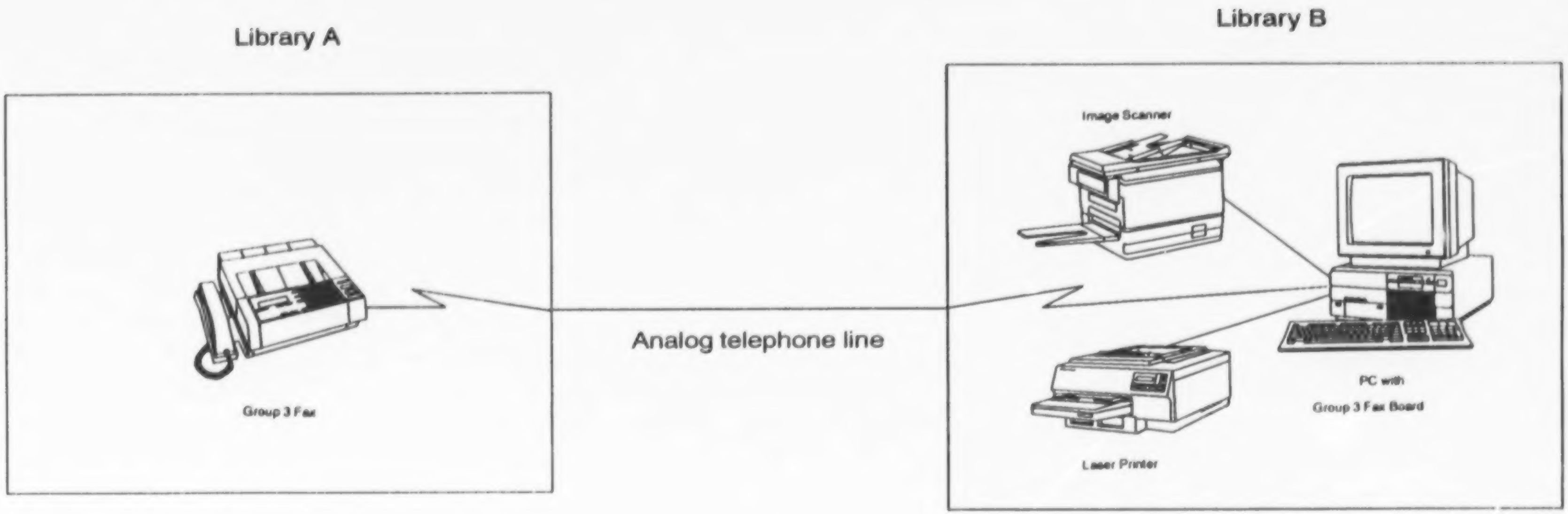

Library A
Group 3 Fax
Analog telephone line
Library B
Image Scanner
PC with
Group 3 Fax Board
Laser Printer

Figure 4-1: Group 3 fax alternatives connected through standard telephone

However, the configuration does have the following disadvantages over a stand-alone fax machine:

- if paper documents are to be used as a source for outgoing fax transmissions, an image scanner must be interfaced to the PC
- if the PC must be kept online to receive unsolicited fax transmissions, then it must have the capability and performance to multitask the fax application with other PC applications, otherwise the PC must be dedicated to the fax application.

While the above two configurations utilize regular telephone lines as the transmission medium, Figure 4-2 illustrates configurations that use digital transmission and Group 4 facsimile.

> ***Library C*** contains a Group 4 fax, a configuration that produces higher resolution images and allows documents to be printed on plain bond paper. In addition, G4 fax uses digital transmission providing libraries with the option of transmitting the images over a digital network.

An alternative to Library C's configuration is to use G3/D (not shown) to send documents either through digital networks to other G3/D machines, or through analog access lines to standard G3 fax machines. G3/D, however, has not yet been accepted as a standard, and no such machines currently exist.

The Network Fax Project, underway at the Instruction and Research Computer Center (IRCC) of the Ohio State University (see Section 5.2.1), plans to use G4 fax to send document images through the *Internet* as part of the project's future developments.

4.1.2 Document imaging systems

A document delivery configuration based on a document imaging system provides a completely electronic approach to the scanning and storage of document images for subsequent retrieval, display, printing and dissemination. Thus, it is a technology appropriate to automate the *retrieval* and *transfer* stages of the document delivery process. Document imaging systems are presently available to libraries to perform on-the-fly document delivery, such as Ariel, the system developed by RLG (see Section 5.2.2 for more information). Document imaging systems may also be used to create databases of the existing paper and microform corpus.

Document imaging configuration

An example document imaging system configuration can be built from several of the technologies described in Chapter 3—image capture systems, workstations, optical storage technologies, and printers. Figure 4-3 presents one possible document imaging system configuration that is suitable for electronic document delivery. The configuration's elements are described below.

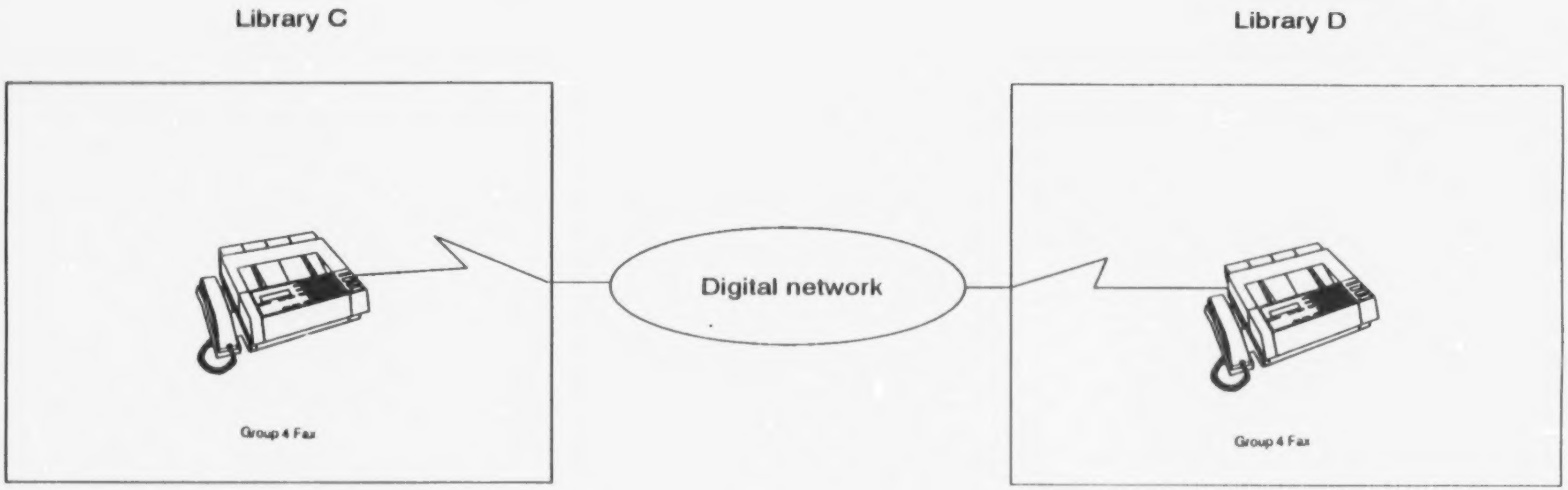

Library C
Library D
Digital network
Group 4 Fax
Group 4 Fax

Figure 4-2: Group 4 fax configuration utilizing a digital network

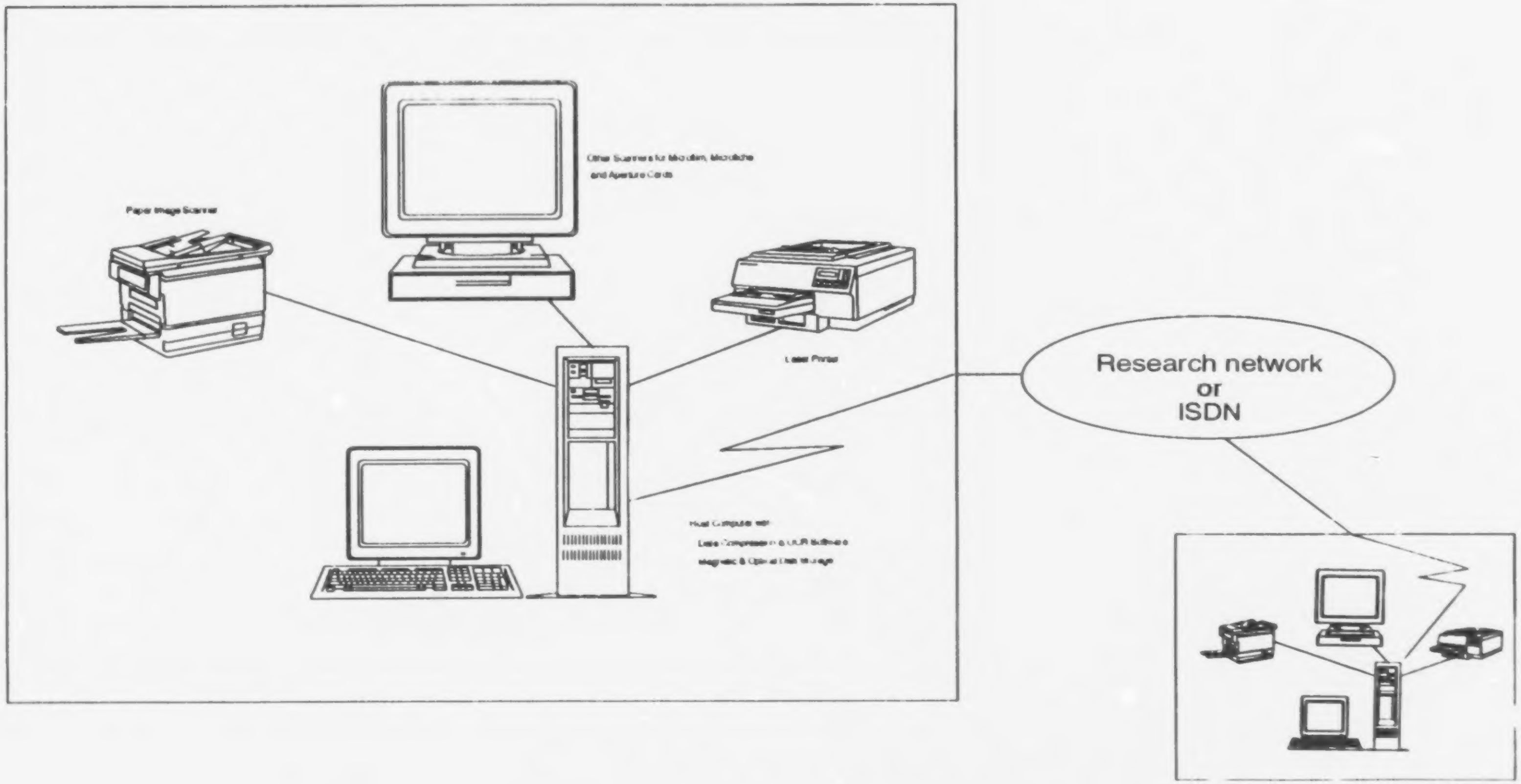

Other Scanners for Microfilm, Microfiche
and Aperture Cards
Paper Image Scanner
Laser Printer
Research network
or
ISDN
Host Computer with
Data Compression & OCR Software
Magnetic & Optical Disk Storage

Figure 4-3: Document imaging system configuration connected to a similar site through a research network

Image capture The document imaging system configuration includes a *paper image scanner* for the conversion of paper images into electronic bitmap images. The configuration also may include scanners other than paper scanners for scanning microfilm, microfiche, aperture cards, and film. Such scanners perform essentially the same function as paper image scanners except that they use other types of media as input. They also possess special features for handling the media such as automatic film advancement, automatic image alignment and automatic card feeding.

Workstations At the heart of the document image system is a *host computer* that provides the primary user interface for controlling the imaging process and contains the software that integrates the various components into a document imaging system. The host computer also performs document compression, optical character recognition (if required for automatic indexing), manages document storage onto magnetic and optical discs, and controls telecommunications.

In operation, the host computer would receive bitmap images from a scanner that would then be stored temporarily on magnetic disk for inspection before being permanently stored. Once the images are inspected and approved, they could be sent immediately to a remote location, or transferred to optical discs for permanent storage.

Storage *WORM* (write once, read many times) optical discs are perhaps the most suitable permanent storage medium for library electronic document delivery applications. For library document storage, erasability is seldom required. An unalterable recording medium, such as WORM, promotes document integrity and provides a document audit trail. Other desirable features of WORM are its high storage capacity of up to 6550 MB per disc and its longevity. In future electronic document delivery architectures, WORM discs will likely be an integral part of the storage hierarchy for the retention of electronic documents

To reduce the amount of disc storage, most document imaging systems employ *data compression* algorithms. Some possible compression schemes have been described in Section 3.1.1.2

Transmission The configuration includes a gateway to a research network, and/or an ISDN network (where available). The images can be transmitted though standard network services, such as file transfer, and received to be later printed at their destinations.

Hard copy production The document imaging system also includes a laser printer for generating hardcopies of the digitized documents when required. The laser printer chosen should possess resolution and grey-scale capabilities at least equal to the capabilities of the scanners to ensure that the hardcopy output quality reaches the full potential that can be derived from the scanned bitmap images.

4.1.3 An ISO ILL Protocol application

Recall from Chapter 2 that ILL messages are sent in a variety of formats through systems that are typically incompatible, such as public electronic mail systems (e.g., ON-TYME II, ALANET), discipline-oriented networks, networks specific to a geographic location (e.g., ILLINET, DOCLINE), and bibliographic utilities (e.g., OCLC, RLIN) (Turner, 1990). Now that the ILL Protocol is a recognized international standard, implementations are likely to begin to appear. An implementation based on the ISO ILL protocol may be used in a transition phase to further facilitate the *requesting* portion of the document delivery process. The requested document may then be sent using document imaging or one of the other transfer configurations discussed above.

Such an implementation may function as follows: once a request has been submitted by a user to a local ILL department, an ILL application based on the ILL protocol can be used to call up standardized forms that are filled in with the appropriate citation information and other transaction details. A communications technology, such as an X.400-based message handling system, can then be used to automatically forward these messages through a network to the lending institution (see Figure 4-4). A peer ILL application at a receiving institution can then accept the message, extract the appropriate data elements, and proceed with further processing.

The advantages of such implementations are similar to those associated with current ILL subsystems, including off-line preparation and storage of messages, and concomitant reductions in clerical activities. In addition, the interoperability offered by the ILL protocol will bring the large number of disparate ILL systems maintained by many libraries into one framework, thereby reducing costs, procedures, and the need for staff training, as well as increasing the scope of potential lending institutions (Turner, 1990).

4.2 Advanced EDD applications

The above example configurations will help redress the imbalance between document access and supply by automating and streamlining aspects of the delivery process in the present and in the transition phase. The ultimate goal, however, will be to create fully integrated electronic document delivery systems that will enable users, whether they are ILL staff or researchers, to select, request, and obtain primary documents from a variety of sources directly from their workstations. These enhanced capabilities will be made possible through the development of an *EDD software application*—a software implementation performing electronic document delivery functions for a human or machine end-user. The EDD application would work within a large networked information environment, allowing access to information both locally, through a campus network or LAN, as well as remotely, through an academic and research network. This networked environment is defined and described in more detail below.

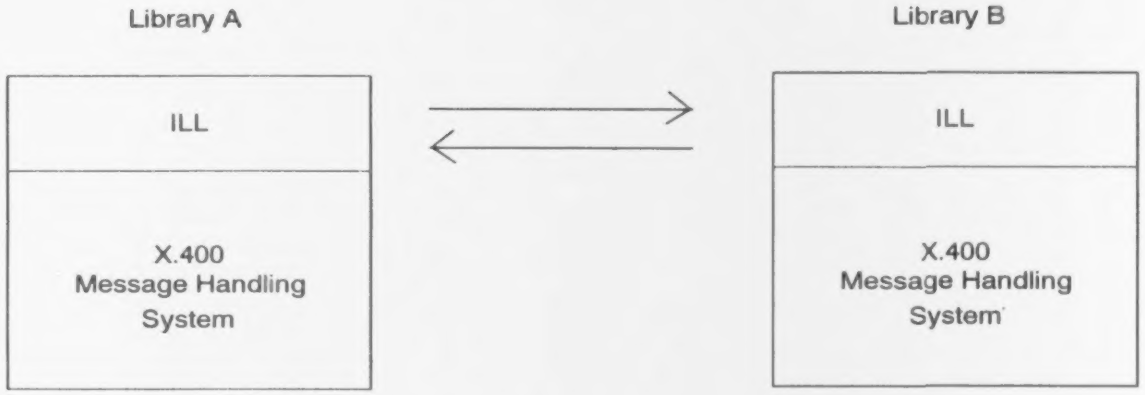

Library A
ILL
X.400
Message Handling
System
Library B
ILL
X.400
Message Handling
System

Figure 4-4: Interlibrary loan transactions via the ILL Protocol carried by an X.400 MHS

The networked information environment

The networked environment in which the EDD application would function would be composed of many educational, research, and commercial institutions interconnected through regional, national, and international computer networks. Figure 4-5 depicts this larger networked information environment which, in this example, includes:

- the ***local information environment***, defined as information and computing resources, connected through a LAN or campus-wide network, under the jurisdiction of a particular institution, such as a library, university, college, or research organization

- ***remote information resources*** consisting of commercial information providers, such as bibliographic database vendors, commercial document suppliers, and publishers; resources such as union catalogues and the information environments encompassed by remote institutions. These elements would be interconnected through regional, national, and international research networks.

Users connected to this information environment thus would be able to locate and obtain electronic documents housed in the local library, a campus document supply centre, or some other institutional resource, as well as those located in outside institutions across a city, across a country, or on another continent. Such a networked information environment is similar that which may develop on high-speed, high-capacity networks such as the NREN.

The remainder of this section will be discussed from the perspective of the *local information environment*. The interoperation of the technologies outlined in the Chapter 3, as well as the workings of the EDD client and server applications, will be illustrated using this local environment. Note, however, that a user is not limited to the local environment, but may as easily access remotely located resources.

4.2.1 The local information environment

The local information environment, shown in Figure 4-6, consists of the information and computing resources under the jurisdiction of a particular institution, such as a library, university, college, or research organization. It is not necessarily tied to an individual library or building, but may consist of resources distributed around a campus or institution. The local information environment contains of a variety of elements:

- ***document input devices***, such as document imaging systems and Group 4 fax

- ***document output devices***, such as laser printers and Group 4 fax

- ***information resources***, such as library catalogues, CD-ROM and locally mounted citation databases, and electronic document databases

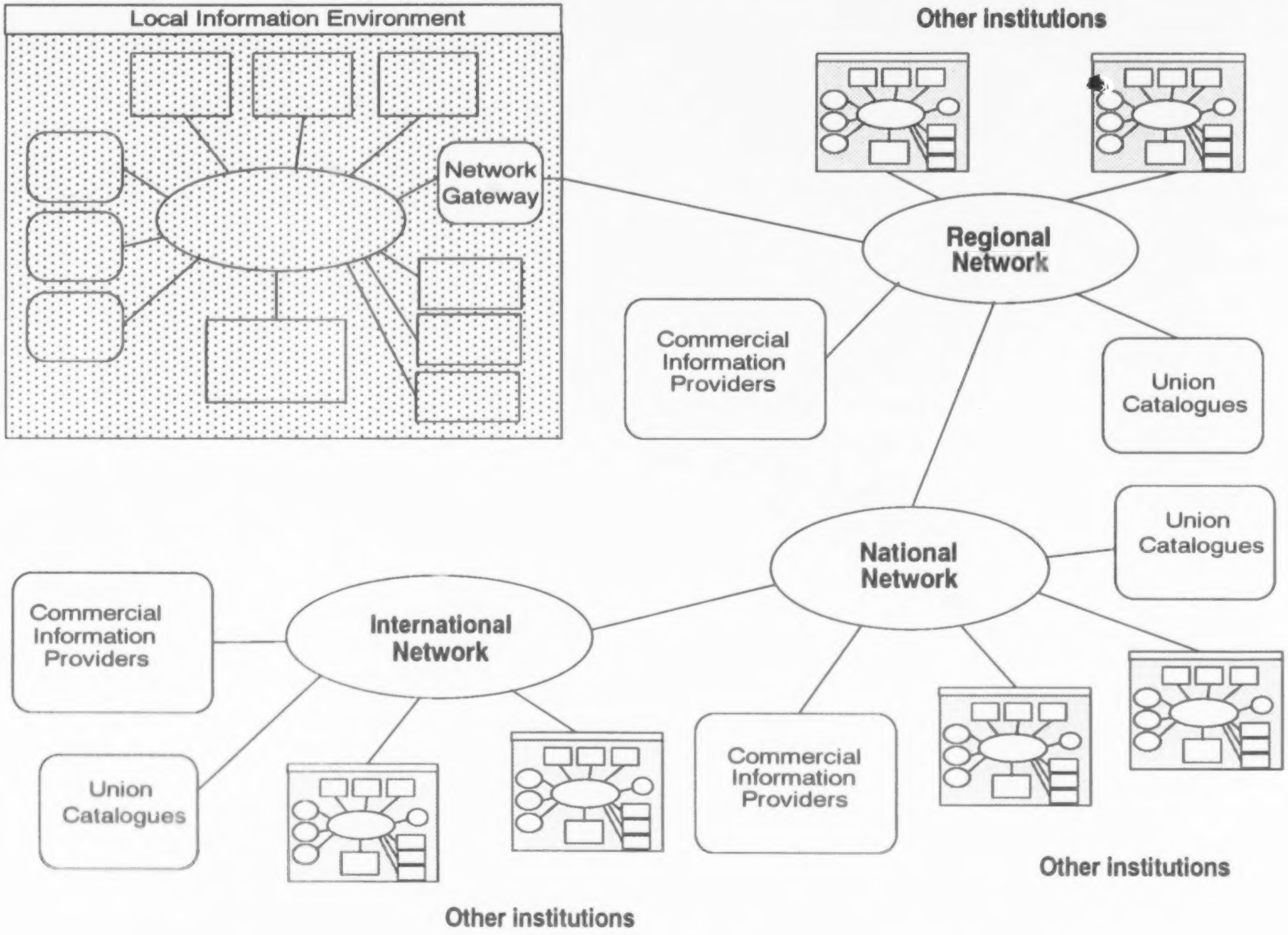

Local Information Environment
Network Gateway
Other institutions
Regional Network
Commercial Information Providers
Union Catalogues
Union Catalogues
National Network
Commercial Information Providers
International Network
Union Catalogues
Commercial Information Providers
Other institutions
Other institutions

Figure 4-5: Networked information environment

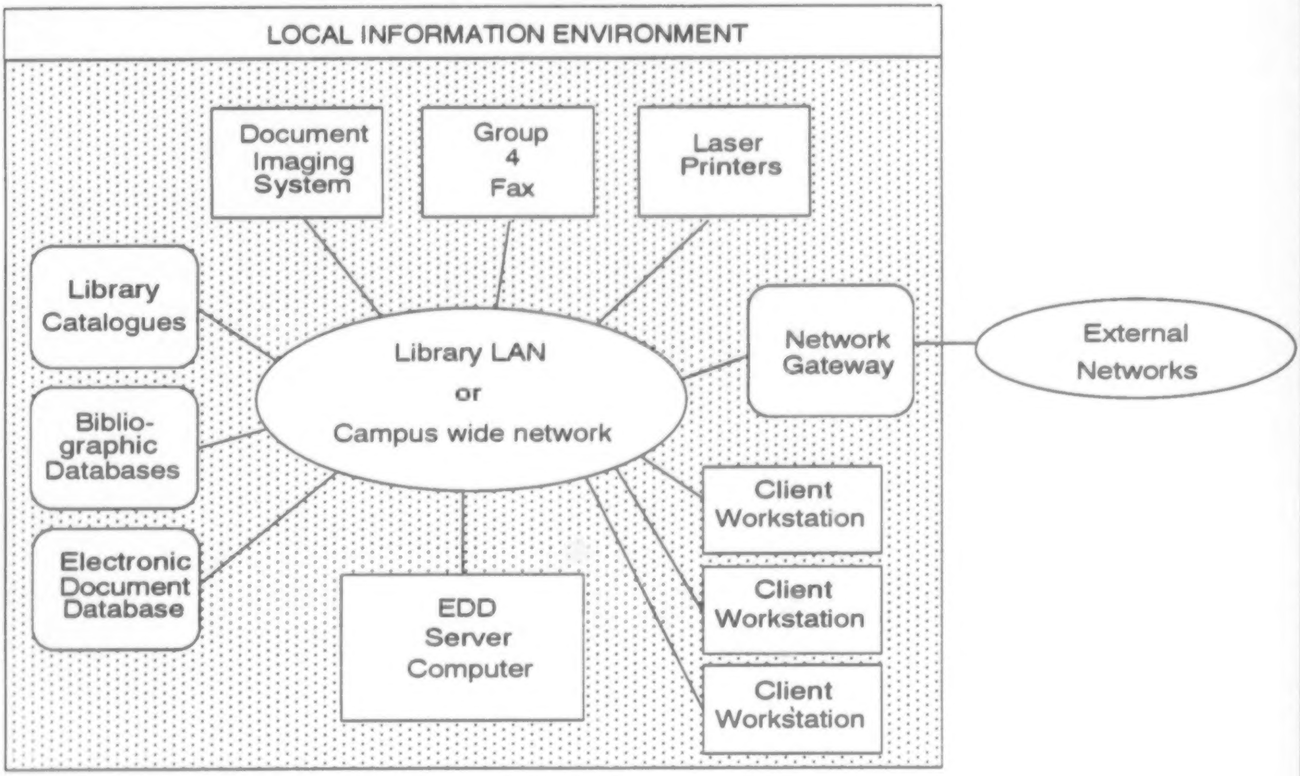

LOCAL INFORMATION ENVIRONMENT
Document Imaging System
Group 4 Fax
Laser Printers
Library Catalogues
Network Gateway
External Networks
Library LAN or Campus wide network
Biblio-graphic Databases
Electronic Document Database
Client Workstation
Client Workstation
EDD Server Computer
Client Workstation

Figure 4-6: Local information environment

- ***communications technologies***, such as an FDDI LAN that provides connectivity, a gateway that supports access to external networks, and a number of application protocols.

Also part of this array is the EDD software application that would coordinate the use of the above elements and perform document delivery functions. The EDD application is divided into client and server components according to the client/server model. Recall that the *client-server* model is the procedure by which two computers cooperatively accomplish tasks on peer-to-peer networks; the clients have their own local computing capability that use resources—filing systems, printers, and communications subsystems—managed by separate systems called servers. Thus, the EDD software application is divided between:

- ***EDD client workstations*** where library patrons or library staff can initiate requests for document searches and for copies of documents

- ***a EDD server computer*** which processes the document requests received from the client workstations

These components are outlined in greater detail below.

4.2.1.1 Document input devices

Figure 4-7 presents a view of the document input devices. These devices consist of document imaging systems and Group 4 fax.

Imaging system As discused in Section 4.1.2, in the near term, *document imaging systems* will be used for converting paper and microform documents into electronic form. Although it is expected that the document conversion role of such systems will diminish, they will likely be used to perform on-the-fly document transmission.

Group 4 Fax Another input device is the *Group 4 fax* machine (with Group 3 compatibility). Such devices will have interfaces that will allow them to send Group 4 fax images directly to computers as well as to other compatible fax machines over a network. Although the document imaging system may also have the capability to convert paper documents into Group 4 fax images, the fax machine will provide a more convenient and efficient alternative. Fax machines will also continue to have their place in on-the-fly transmission.

4.2.1.2 Document output devices

Figure 4-8 presents a view of the document output devices. These devices consist of laser printers and Group 4 fax.

Laser printers Until an adequate electronic replacement for paper documents becomes available that offers all the conveniences of paper documents (such as portability, easy marking and annotation, and the lack of a need of special tools to read the documents), hardcopy output

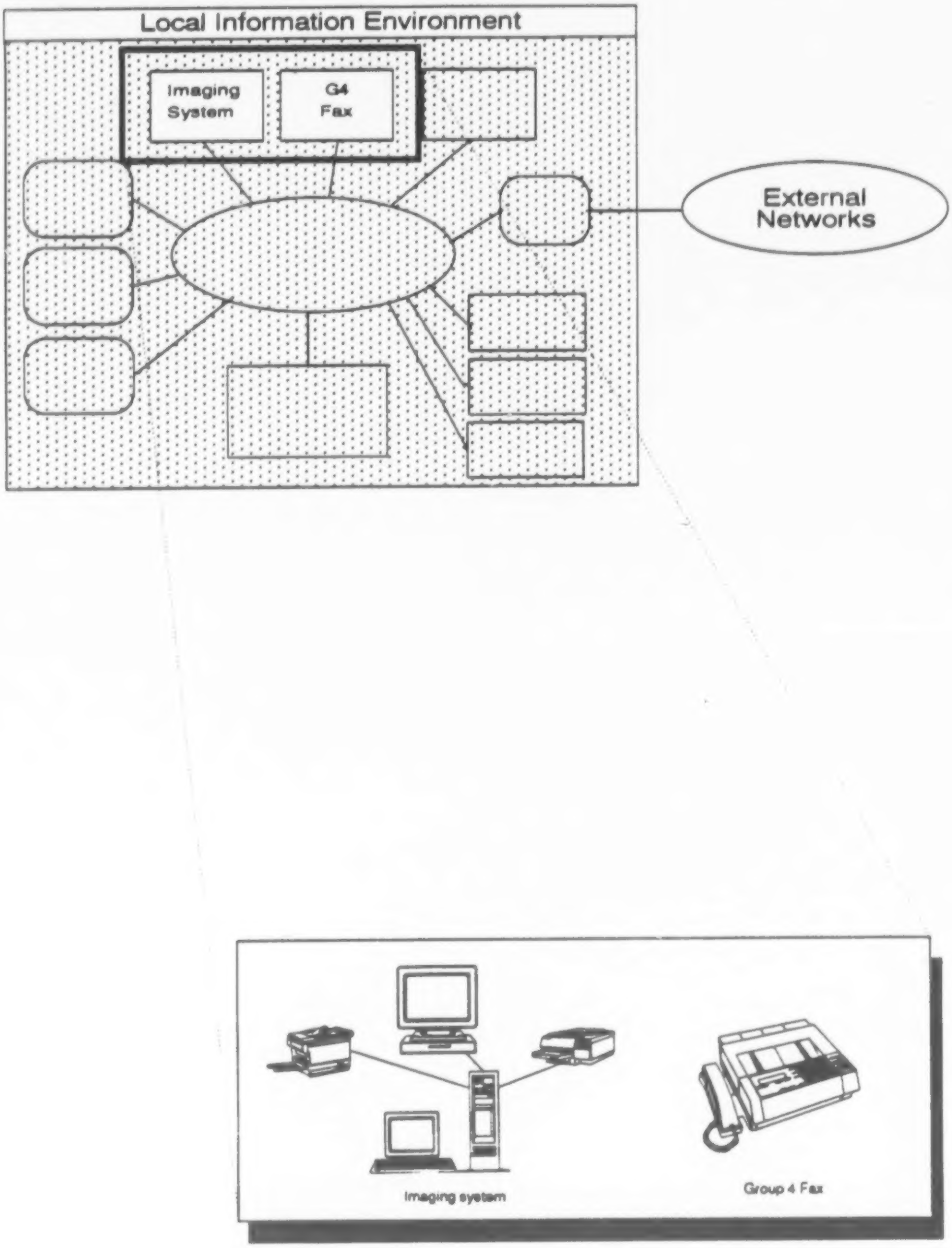

Local Information Environment
Imaging System
G4 Fax
External Networks
Imaging system
Group 4 Fax

Figure 4-7: Document input devices

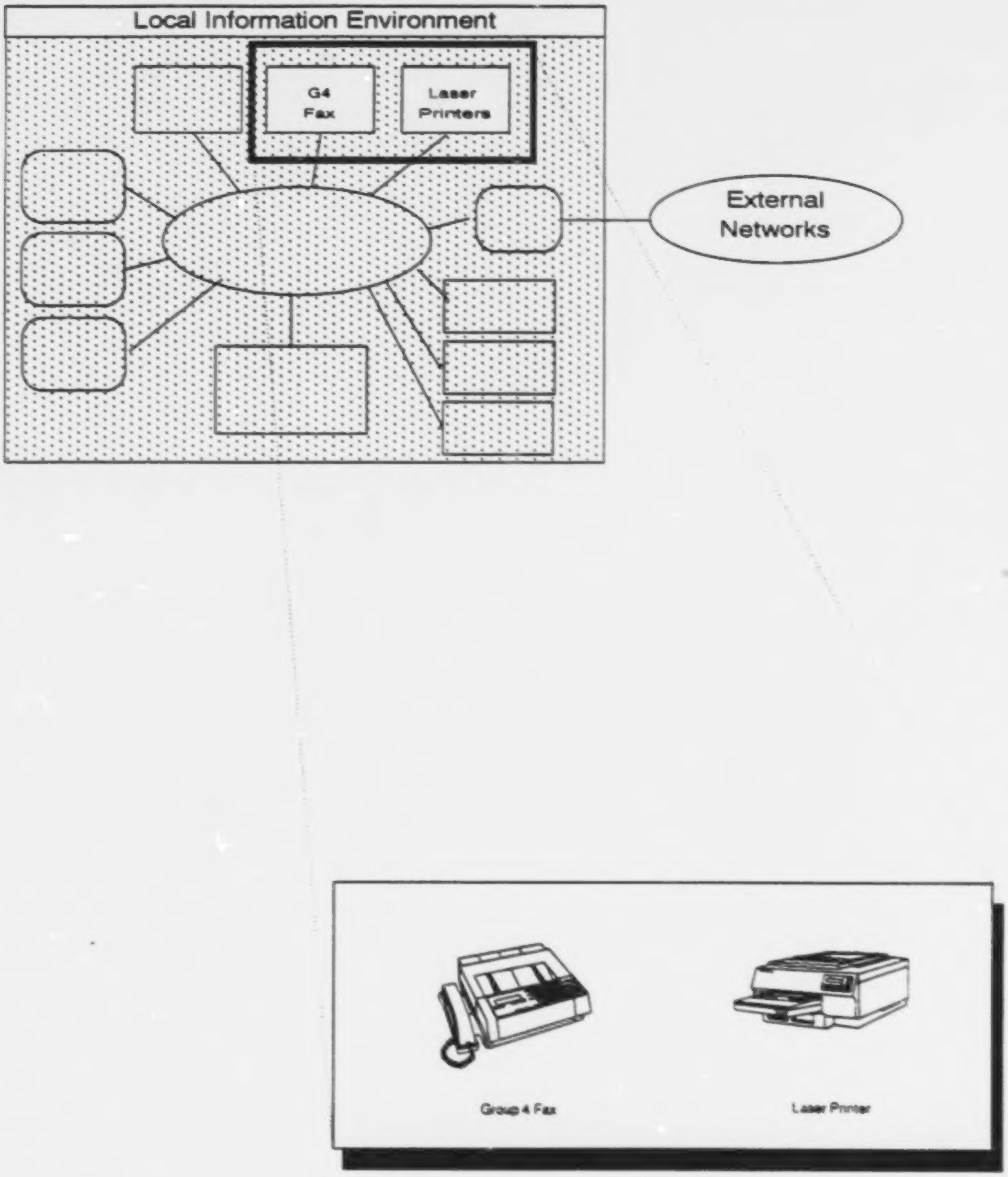

Local Information Environment
G4 Fax
Laser Printers
External Networks
Group 4 Fax
Laser Printer

Figure 4-8: Document output devices

devices will continue to have a role in integrated electronic document delivery architectures. For the user who will occasionally print his/her own documents, the most likely output device will be monotone and colour laser printers located at the user's desk; slow printing speeds and limited resolution may restrict the amount of printing a user will perform. For more centralized approaches, in which documents are received electronically by libraries or campus document delivery services and forwarded in hardcopy form to users, higher-end systems, such as Xerox's DocuTech Series, may be more appropriate.

Group 4 Fax Depending on the evolution of Group 4 fax machines, they may also play a significant role as a laser printer-type hardcopy output device. Thus, with the addition of colour laser printers and Group 4 fax machines, users will have an even wider selection of hardcopy output qualities to choose from.

4.2.1.3 Information and document resources

Figure 4-9 presents a view of the local information resources that will be available to the EDD application. These include:

- ***the library catalogue***, containing the local holdings within the user's own library or library system

- ***indexing and abstracting databases*** (I&A databases) mounted locally as well as those held on CD-ROM

- ***electronic document databases*** consisting of electronic documents held in a variety of formats including Group 3 and 4 facsimile, TIFF and JPEG for scanned images, Office Document Architecture (ODA), Standard Generalized Markup Language (SGML), Standard Page Description Language (SPDL), ASCII/IA5 text, and proprietary formats (such as WordPerfect, Microsoft Word and PostScript), as well as multimedia documents.

4.2.1.4 Communications technologies

Figure 4-10 presents a view of the communications technologies that will interconnect the elements of the local and external library environment.

LAN A backbone LAN, in this case based on FDDI technology, provides connectivity for all of the elements located in the local environment. While many other LAN technologies exist that may support connectivity in the local information environment, FDDI has been chosen because of its high channel capacity of up to 100 Mbps.

Gateway A gateway provides access to a high-speed research network to interconnect other libraries, institutions, and client sites. The gateway consists of hardware and software to support interconnection between network technologies such as FDDI, frame relay, ISDN or B-ISDN, or some form of research network.

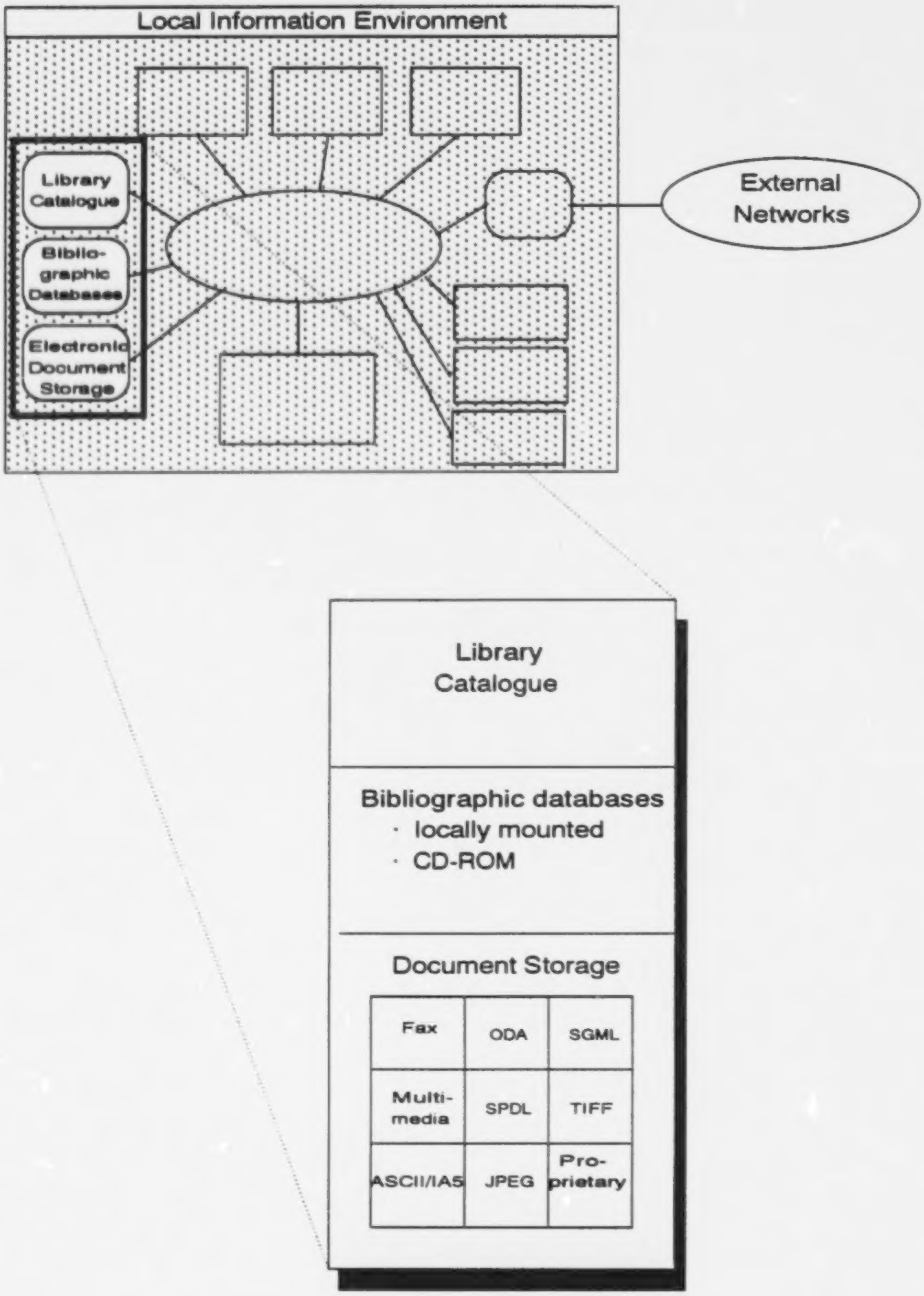

Local Information Environment
Library Catalogue
Biblio-graphic Databases
Electronic Document Storage
External Networks
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII/IA5
JPEG
Pro-prietary

Figure 4-9: Local information resources

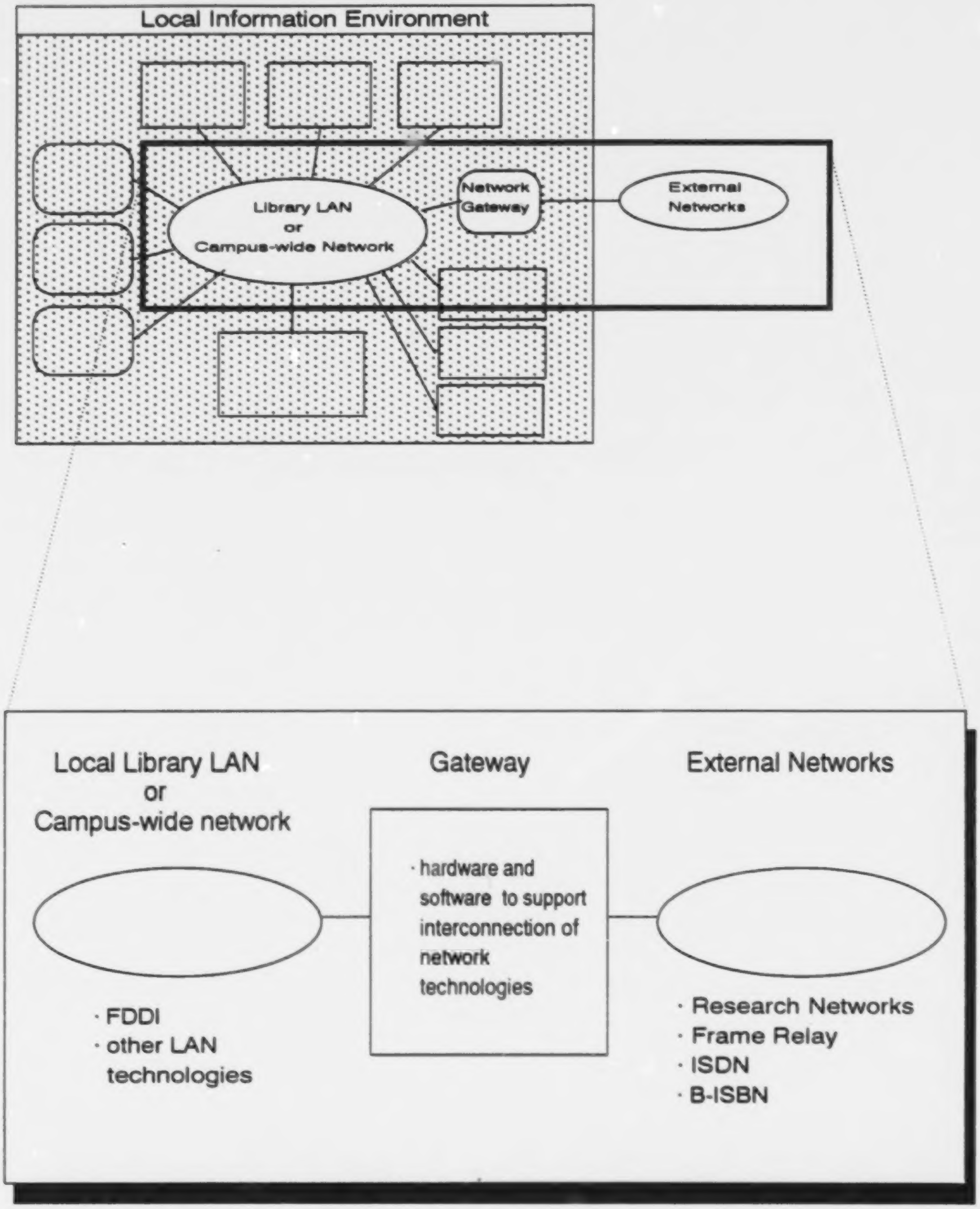

Local Information Environment
Library LAN
or
Campus-wide Network
Network
Gateway
External
Networks
Local Library LAN
or
Campus-wide network
Gateway
External Networks
· hardware and
software to support
interconnection of
network
technologies
· FDDI
· other LAN
technologies
· Research Networks
· Frame Relay
· ISDN
· B-ISBN

Figure 4-10: Communications options

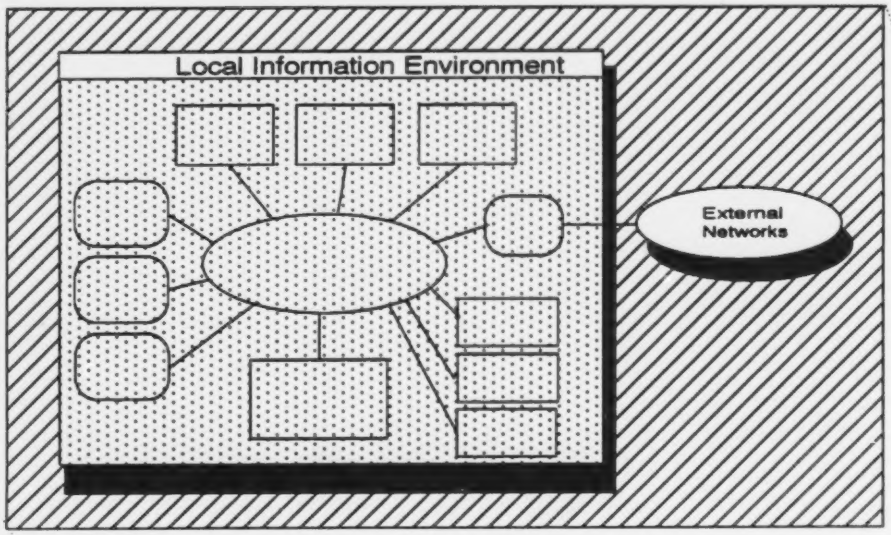
External networks The long-haul communications medium in this configuration is a high-speed, high-capacity research network, such as the proposed National Research and Education Network (NREN), in order to connect with other libraries and institutions. Networks that serve the educational and academic communities provide the benefit of access to a large user community, and planning is underway to increase their capacity quickly to meet the needs of applications such as electronic document delivery. Such networks have been envisioned as the basis of advanced information networks that would satisfy the information needs of scholars, students, and researchers. Alternatively, libraries may choose to implement high-speed technologies such as *frame relay* (based on 1.544 Mbps T1 technology), *ISDN* (providing a channel capacity of 64,000 bps) or *B-ISDN* (providing a channel capacity of 155 Mbps).

Application protocols

Figure 4-11 depicts the OSI application layer protocols that underlie all network communications in the local and remote environments. These protocols either directly support the transfer of electronic documents, or provide communications capabilities related to electronic document delivery. As electronic document delivery focuses on the interchange of electronic documents, this is a key technology to support that interchange. OSI application layer protocols available for electronic document delivery include:

- ***FTAM, DFR, DTAM***, protocols defining the synchronous exchange of files and documents between remote computers
- ***X.400***, a protocol that defines message handling systems that assist users in the preparation, asynchronous exchange, and filing of electronic messages
- ***ILL Protocol***, the standard based on the OSI reference model that defines the exchange of ILL messages
- ***EDI***, a series of standardized message formats, primarily oriented toward business transactions, used for inter-system communications
- ***Z39.50/SR***, a protocol specifies how, and in what form, search requests and results will be managed between a client and server, allowing multiple databases to be accessed in a mode native to the local search system
- ***X.500***, a set of CCITT Recommendations defining a distributed database for OSI applications containing information about people, applications, and devices, and provides structured mechanisms for accessing the information.

If none of these protocols satisfy a particular need, custom electronic document delivery protocols could be developed that interface directly to the LAN/WAN communication services. The interaction of these protocols is discussed in a later section.


Local Information Environment
External Networks

OSI Application Protocols

- protocols that either directly support the transfer of electronic documents or provide communications capabilities related to electronic document delivery.
- underlie network communications throughout the local and remote information environments

FTAM
DTAM
DFR

X.400

ILL

EDI

Z39.50/SR

X500
Directory

Figure 4-11: Application protocols available througout both local and remote information environments

4.2.1.5 The EDD server computer

At the heart of the integrated electronic document delivery system is the *server computer*. Recall that EDD servers are those computers that process the document requests received from the client workstations. The server computer will support the EDD server application software that will interact with elements within the local information environment and external users.

EDD Server application software

At the core of the server computer are the *EDD server programs* that provide the "glue" to integrate the various technologies. These EDD server programs perform application-specific functions on behalf of their clients, specifically, those relating to selecting, requesting, retrieving, and transferring electronic documents. In so doing, the server programs use the technologies in a *seamless manner*, according to the needs of each particular application. One can visualize this environment in terms of: 1) a set of application programming interfaces (APIs), each related to a particular capability provided by one of the technologies; and 2) a set of main programs, representing the server programs, that incorporate these APIs and coordinate their use.

Figure 4-12 shows the technologies and APIs utilized by the EDD server application in the local information environment. These elements are assembled in Figure 4-13 into a logical representation of the "seamless" environment. They include communications technologies, information resources (e.g. bibliographic databases and electronic documents), and document input and output systems.

Communications technologies It is important to note that most the OSI application protocols (depicted Figure 4-11) were not developed to meet the specific needs of electronic document delivery. Rather, they were developed to serve the particular communication needs of a broad range of applications. Therefore, one of the central tasks of the EDD server programs would be to coordinate the use of these protocols in a manner appropriate to the electronic document delivery context. For example, an ILL application program could integrate the use of the SR and ILL protocols by supporting access to a bibliographic catalogue via the SR protocol, and the posting of an ILL request using the ILL protocol, all within a single communications session. The achievement of this coordination may, in some cases, require the definition of some EDD-specific extensions to existing standard specifications in order to fully meet the requirements of electronic document delivery. For example, existing FTAM document types do not address the requirement to correlate a transferred document to the ILL request that triggered the document transfer in the first place; this need can be met by defining an electronic document delivery-specific document type that allows the necessary correlation information to be conveyed.

Coordination of the application protocols is not restricted to the server programs. OSI application layer protocols may invoke each other in order to perform their functions. As discussed in Chapter 3, EDI messaging, as defined in CCITT Recommendation X.435, uses the services of the X.400 Message Transfer Service. ILL similarly may use X.400 to transfer its messages. X.500 services will be used by most other protocols to look up addressing information.

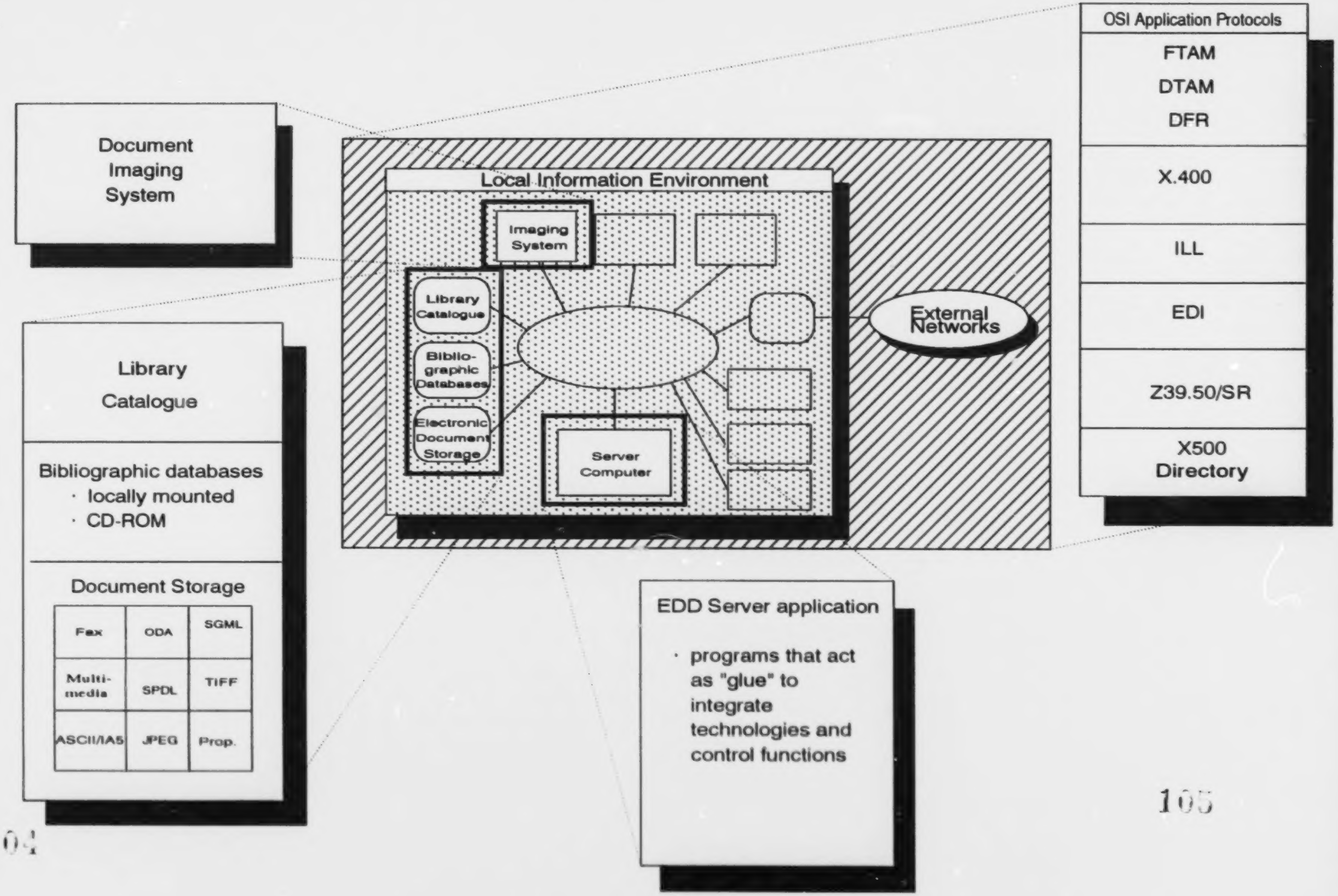

Document Imaging System
Local Information Environment
Imaging System
Library Catalogue
Biblio-graphic Databases
Electronic Document Storage
Server Computer
External Networks
OSI Application Protocols
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII/IA5
JPEG
Prop.
EDD Server application
· programs that act as "glue" to integrate technologies and control functions

Figure 4-12 Technologies utilized by the server application software

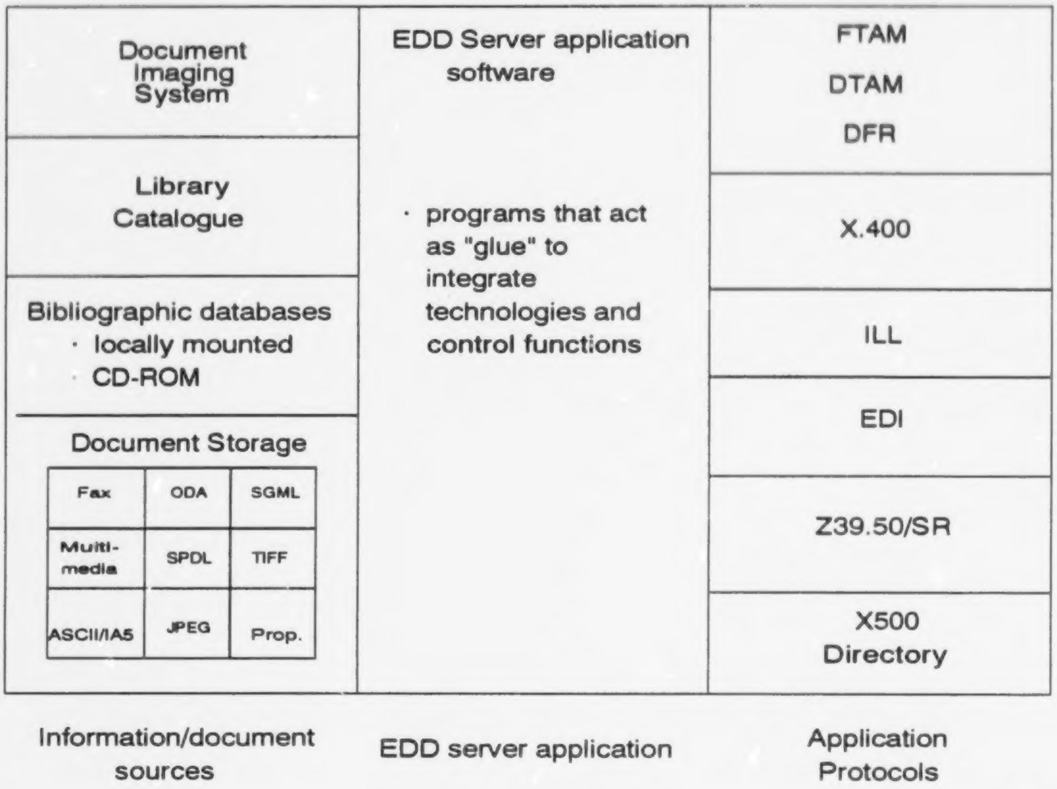

Document Imaging System
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII/IA5
JPEG
Prop.
EDD Server application software
· programs that act as "glue" to integrate technologies and control functions
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Information/document sources
EDD server application
Application Protocols

Figure 4-13: Logical representation of "seamless" server application environment showing elements available to the server application

Information resources Bibliographic databases and electronic documents in various formats will be made available in on-line storage devices. An important consideration is that the EDD server will likely have to make electronic documents available in several formats to maximize the exchange of documents with other libraries, publishers, and library patrons. This reflects the objective of the EDD server to support access to a full range of electronic documents generated by a variety of means, including image capture of existing paper and microform documents, text processing and desktop publishing systems, as well as publishing house systems.

Although Figure 4-12 suggests that documents are stored in several different formats, it is highly desirable to minimize the number of different document storage formats in order to: 1) to reduce the complexity of the implementation; and 2) to reduce document storage requirements by avoiding the storage of multiple copies of documents in different formats. This can be achieved in two ways:

- ***limit formats*** Agreement within the EDD community on a limited number of document formats to meet the widest range of application needs. This is certainly one of the major stimuli behind the standardization efforts that have led to the development of the various document-related standards within ISO and CCITT. This has also led to the formation of industry groups, such as the Group on Electronic Document Interchange (GEDI), to agree on a common document image format for interim use within the library community

- ***provide conversion capabilities*** Where application requirements differ, or political and other considerations dictate the need to support multiple formats, then adopt a minimum of storage formats internally within a server, and provide conversion capabilities to other formats when transferring documents externally. For example, still images may be encoded internally according to the JPEG compression algorithm, with a capability to expand the stored image to its original form and re-compress it according to different algorithms depending on the image handling capabilities of the target system to which an image is to be transferred. Similarly, a single document representation format may be used internally (e.g., in a proprietary format), with a conversion capability to other formats, such as ODA or SGML, for document transfer purposes. This is already a common feature of many proprietary document preparation packages, and many vendors are developing translators to and from the ODA interchange format. An important consideration in adopting this approach is to ensure that the local storage representation is sufficiently comprehensive to support conversion to other formats without significant loss of information.

The document formats that will be widely implemented will be driven largely by the standards community, industry, and the consumer market.

Input/output systems In addition to integrating technologies related to the storage/representation and interchange of documents, the EDD server programs need to coordinate interactions with local input subsystems. Examples of such subsystems are the document imaging subsystem, printers and Group 4/3 fax machines. Documents stored on-line can be sent to the document imaging subsystem for permanent off-line storage on optical disc. The interface to the printer can provide print spooling to several printers of various output qualities. Via the fax interface, the EDD server may receive Group 4 (or 3) fax images from the fax machine or send documents to the machine for fax transmission.

4.2.1.6 EDD client workstations

EDD client workstations are the computers where library staff or library patrons can initiate requests for document searches and for copies of documents. EDD client workstations may reside locally connected to the LAN, or remotely, connected to external networks. It is important to stress that servers and client workstations may intercommunicate regardless of whether they are situated within the local information environment or within the remote information environment, such that:

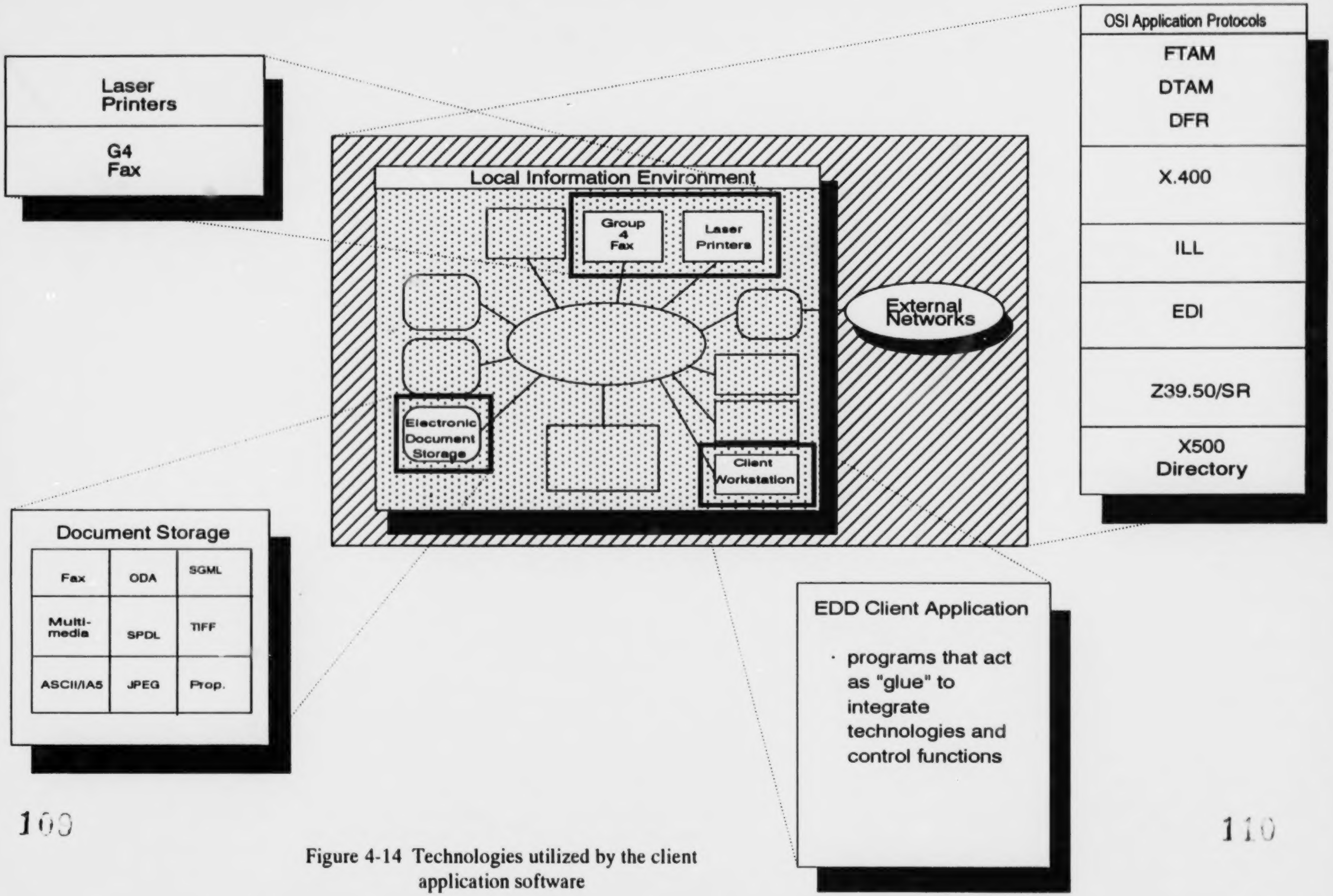
- an EDD client workstation may utilize an EDD server computer that is located on the local library LAN or campus-wide network
- an EDD client workstation may utilize an EDD server computer that is located on a remote (i.e., at another institution) library LAN or campus-wide network

The corollary is that the local EDD server may be utilized by remote client workstations as well as those that are part of the local library or campus environment. Whether the EDD client workstations are located locally or remotely, the technologies that implement them will be identical with the only exception being the specific technologies used to connect to the network.

EDD client application software

Figure 4-14 presents the technologies and APIs in the local information environment utilized by the EDD client application. These elements are assembled in Figure 4-15 into a logical representation of the "seamless" environment. They include communications technologies, electronic documents stored in various formats in on-line storage devices, document output devices, and a user interface. This diagram follows very closely the form of the diagram for coordination of software for the EDD server. Again, the set of EDD client programs is the "glue" to integrate the various technologies.

Communications technologies As with the EDD server programs, the EDD client programs will also utilize specific OSI application layer protocols to perform specific electronic document delivery tasks. Because they are peer-to-peer protocols, the EDD client OSI application layer protocols will essentially mirror the EDD server OSI application layer protocols. The difference will be in the operational modes of the protocols. In general, the EDD client protocols will operate in a "client mode" initiating requests such as document search or borrow requests. The EDD server protocols will operate in a "server mode" responding to requests with answers such as document search results or copies of documents. This interaction is outlined in a subsequent section.


Laser
Printers
G4
Fax
Local Information Environment
Group 4 Fax
Laser Printers
External Networks
Electronic Document Storage
Client Workstation
OSI Application Protocols
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500
Directory
Document Storage
EDD Client Application

Document Storage

Fax	ODA	SGML
Multi-media	SPDL	TIFF
ASCII/IA5	JPEG	Prop.

EDD Client Application

- programs that act as "glue" to integrate technologies and control functions

Figure 4-14 Technologies utilized by the client application software

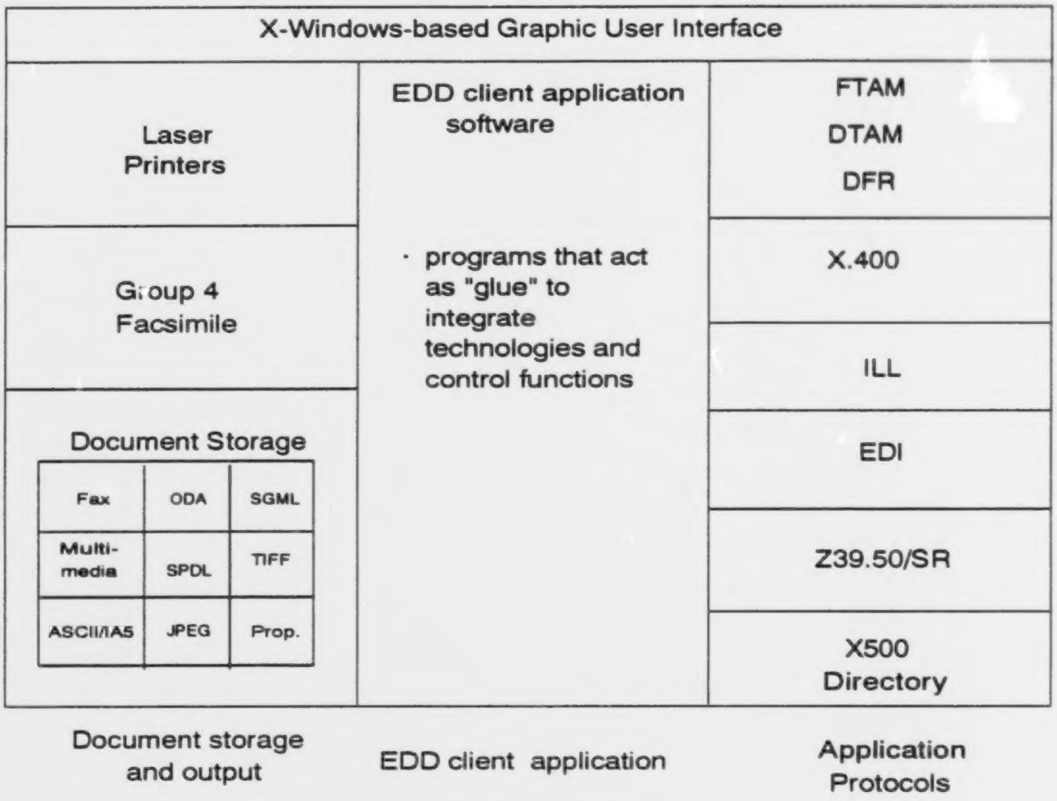

X-Windows-based Graphic User Interface
Laser Printers
Group 4 Facsimile
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII/IA5
JPEG
Prop.
EDD client application software
· programs that act as "glue" to integrate technologies and control functions
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Document storage and output
EDD client application
Application Protocols

Figure 4-15: Logical representaion of "seamless" client application environment showing elements available to the client application

Document formats Whereas the EDD server software environment must make documents *available* in several document formats, the EDD client software will require the capability to *receive and display* documents in at least one of the formats provided by the EDD server. Thus, the EDD client will support software for the storage, retrieval, conversion and display of documents stored in various formats such as ODA, SGML, SPDL, Group 3 and 4 fax, TIFF and JPEG, PostScript, as well as multimedia documents.

User interface EDD client programs will also utilize user interface technologies, for example, graphical user interface (GUI) software such as X Windows and Motif. X Windows could be used to provide the user with an intuitive, easy-to-use graphical user interface to all of the EDD client functions.

Document output devices A laser printer or G4 fax might be available for the occasional printing of hardcopies at the client workstation, in addition to more high-end equipment, such as Xerox's DocuTech Publishing Series, that may be available at the library or campus document delivery service.

4.2.2 Operation

The preceding section provided an overview of the elements that form the local information environment including document input devices, document output devices, information resources, communications technologies, as well as the EDD server and the EDD client workstations. The following section will illustrate how these various elements will interact during the stages of the document process. The logical representations of the EDD client and server application environments developed in Sections 4.2.1.5 and 4.2.1.6 are used to illustrate the selection, requesting, retrieval, and transfer of a document.

4.2.2.1 Document selection

In general, the Z39.50/SR and/or the X.500 protocol can be used to support document searches. For example, an EDD application may be constructed using X.500 to assist the user in discovering the locations of information resources available on the network. X.500 itself, or implementations of SR, would then allow the user to engage in information retrieval in a number of databases on the network with a single user interface. The SR or X.500 application would then return a result set and present it to the user in a manner native to the local system. At this point, the user could examine the resultant set of citations for relevant material. Further extensions could be developed to allow the user to determine the form of the primary electronic document linked to the citation; that is, whether it is a scanned imaged (as well as its resolution), or whether the document is represented in ODA, SGML, or SPDL.

To show specifically how the various technologies would cooperate with one another during the selection or access stage of document delivery, two examples have been formulated: access through X.500 and access through Z39.50/SR.

X.500 example

Figure 4-16 shows the elements active during the X.500 transaction and the direction of the flow of information. Shaded areas are not active. The steps involved during access based upon the X.500 protocol are as follows:

Step 1 A document search request is initiated from the remote EDD client workstation by a user interacting with a GUI interface. A typical request might be "articles written by John Doe" or "books about World War II". The EDD client workstation uses the X.500 protocol to transmit the request. The request is sent over a high-speed network to the destined library EDD server.

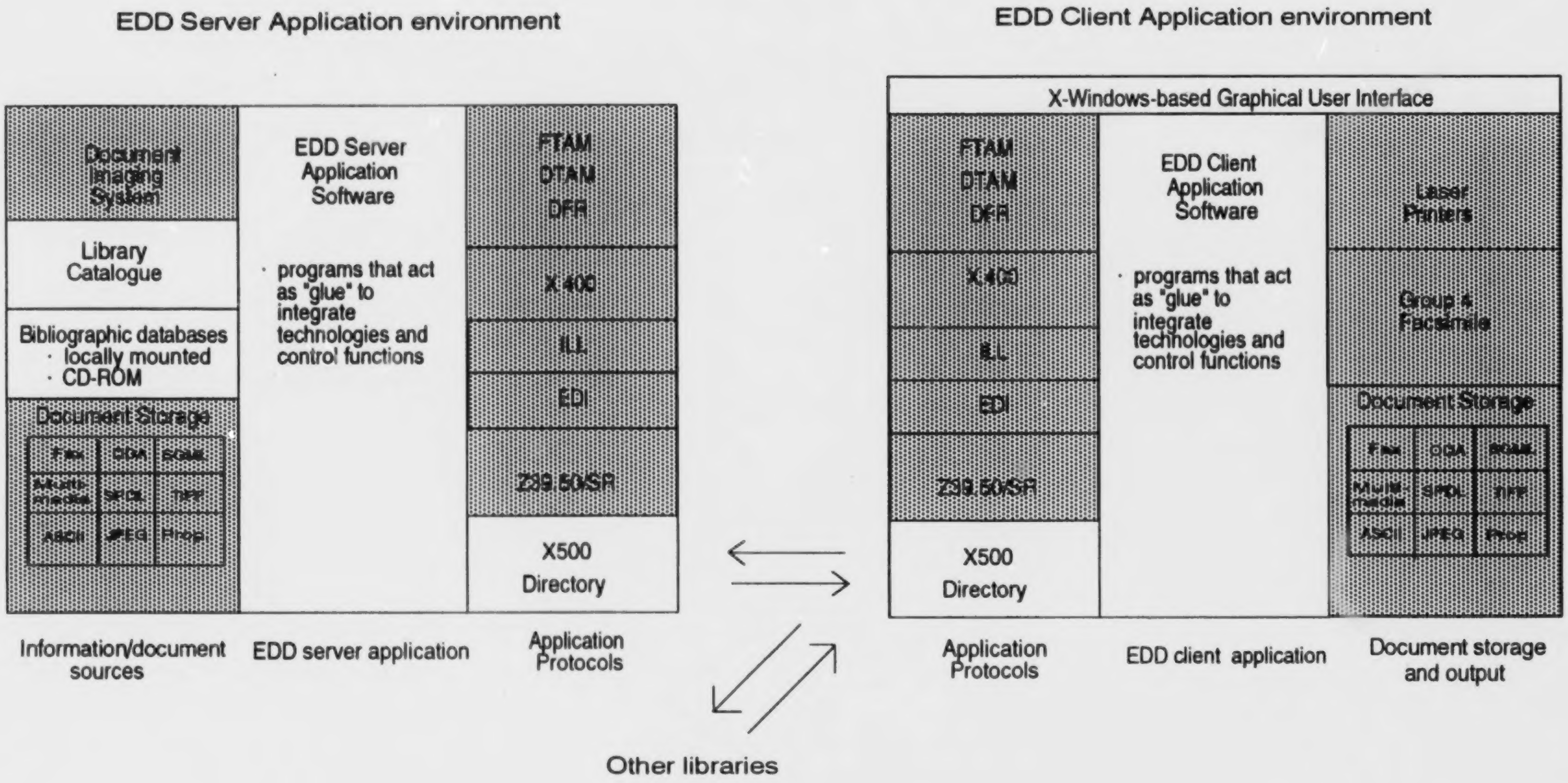
Step 1A The document search request is received by the library EDD server via the X.500 protocol and processed. The document index and attribute data is stored in an X.500 *directory information base (DIB)* residing on the server's fixed magnetic disk (not shown). The library catalogue and any relevant bibliographic databases are checked. In this case, the search produces no matches and, as a result, duplicate requests are *multicasted* via X.500 over the network to other libraries that might be able to satisfy the request.

Step 1B The document search is received by other libraries. At least one of the searches results in matches. The result sets are returned via X.500 over the WAN to the original library EDD server.

Step 2 The result sets are received by the original EDD server. The EDD server answers the original EDD client request with the result sets via X.500 over the WAN.

A single cycle of the above search scenario may not provide sufficient information to proceed to the request stage of delivery. For example, subsequent search scenarios might be initiated to obtain further information such as:

- an indication whether an electronic version of a document is only, optionally, or conditionally available
- an indication of document quality in terms of encoding (bi-level, grey-scale, or colour) and image resolution
- an indication of the available document formats such as Group 3 and 4 fax, ODA, SGML, SPDL, ASCII/IA5 text, or proprietary formats (such as WordPerfect, Microsoft Word and Wordstar)
- an indication of the supported document delivery services such as FTAM, DFR, DTAM, or X.400 over a WAN, or Group 4 fax over PSDN or ISDN


EDD Server Application environment
Document Imaging System
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
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Multi-media
SPDL
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ASCII
JPEG
Prop.
EDD Server Application Software
· programs that act as "glue" to integrate technologies and control functions
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Information/document sources
EDD server application
Application Protocols
EDD Client Application environment
X-Windows-based Graphical User Interface
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
EDD Client Application Software
· programs that act as "glue" to integrate technologies and control functions
Laser Printers
Group 4 Facsimile
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop.
Application Protocols
EDD client application
Document storage and output
Other libraries

Figure 4-16: Logical representation of elements active during document selection - X.500 example
Unshaded areas are active, shaded areas are not.

- an indication of the price and lead time
- an indication of the constraints on use, reproduction and modification.

The above X.500 access scenario demonstrates how the X.500 protocol, and particularly its distributed and location independent directory features, can be beneficial during the access stage of electronic document delivery. However, the nature of the search capabilities of X.500 makes this protocol most appropriate for known item searches—when the requester can provide information that exactly describes the desired document, such as an ISBN or ISSN.

Z39.50/SR example

Figure 4-17 shows the elements active during a transaction based on Z39.50/SR—a protocol designed specifically for general purpose information retrieval—and the direction of the flow of information. Shaded areas are not active. The steps in a Z39.50/SR example are very similar to those of the X.500 example, however, the following differences in the capabilities of the protocols causes basic operation to be dissimilar:

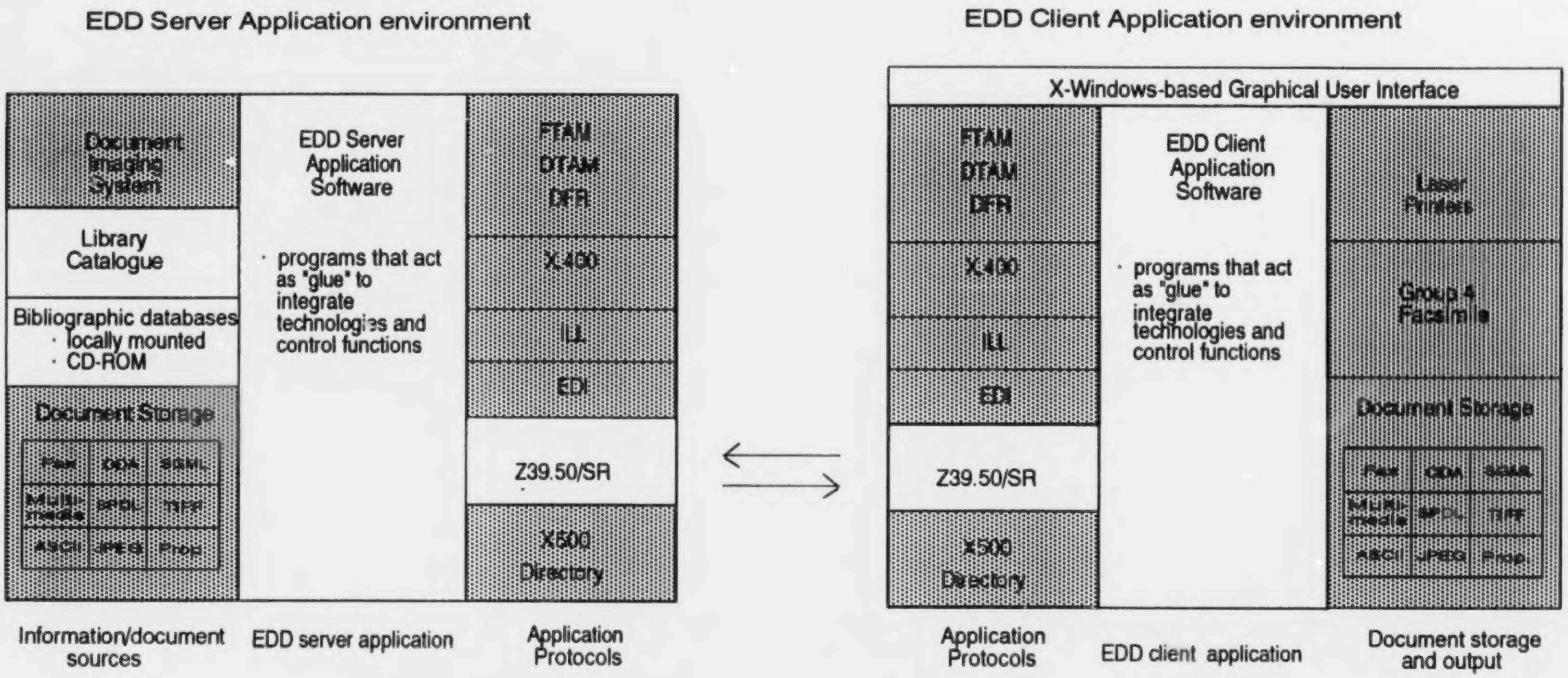
- the Z39.50/SR protocol does not have the distributed and location independent database lookup features of X.500
- the Z39.50/SR protocol possesses *resource control functions* that X.500 does not.

Resource control allows the server to notify a client that a search will take a long time or will produce a large result, and to request confirmation from the client that the server should proceed to process the query. The steps in this example are as follows:

Step 1 A document search request is initiated from the remote EDD client workstation. The EDD client workstation uses the Z39.50/SR protocol to transmit the request. The request is sent over the high-speed WAN to the destined library EDD server.

Step 2 The document search request is received by the library EDD server via the Z39.50/SR protocol and is partially processed. The document index and attribute data is stored in a database residing on the server's fixed magnetic disk. An estimate of the time to complete the query and the number of records that will match the query are calculated. The resource control information is returned via Z39.50/SR over the WAN to the EDD client workstation.

Step 3 The EDD client workstation user receives and evaluates the resource control information. The user decides to proceed with the query and sends confirmation via Z39.50/SR over the WAN to the EDD server.



EDD Server Application environment
Document Imaging System
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
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SGML
Multi-media
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X500 Directory
Information/document sources
EDD server application
Application Protocols
EDD Client Application environment
X-Windows-based Graphical User Interface
FTAM
DTAM
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X.400
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EDI
Z39.50/SR
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SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop
Application Protocols
EDD client application
Document storage and output

Figure 4-17: Logical representation of elements active during document selection - Z39.50/SR example. Unshaded areas are active, shaded areas are not.

Step 4 The EDD server receives the confirmation and proceeds with completing processing of the original query by searching the library catalogue and/or bibliographic databases. The EDD server then answers the original EDD client request with the result set via Z39.50/SR over the WAN.

4.2.2.2 Requesting

In general, the ILL Protocol can be employed to exchange interlibrary loan messages between document sources. For example, citation information of selected documents could be tagged by the user and submitted automatically to an ILL sub-function. The request information could be automatically forwarded to a document source where a peer application would accept and process the request according to library policy/management considerations.

For associated business transactions, if applicable, EDI messaging can be used to exchange structured processable information, such as order and invoice information exchanged between publishers and/or users and libraries.

To illustrate specifically how the technologies would cooperate with one another during the request stage of delivery, an example of a typical requesting procedure is presented below. Figure 4-18 shows the elements active during the transaction and the direction of the flow of information. Shaded areas are not active.

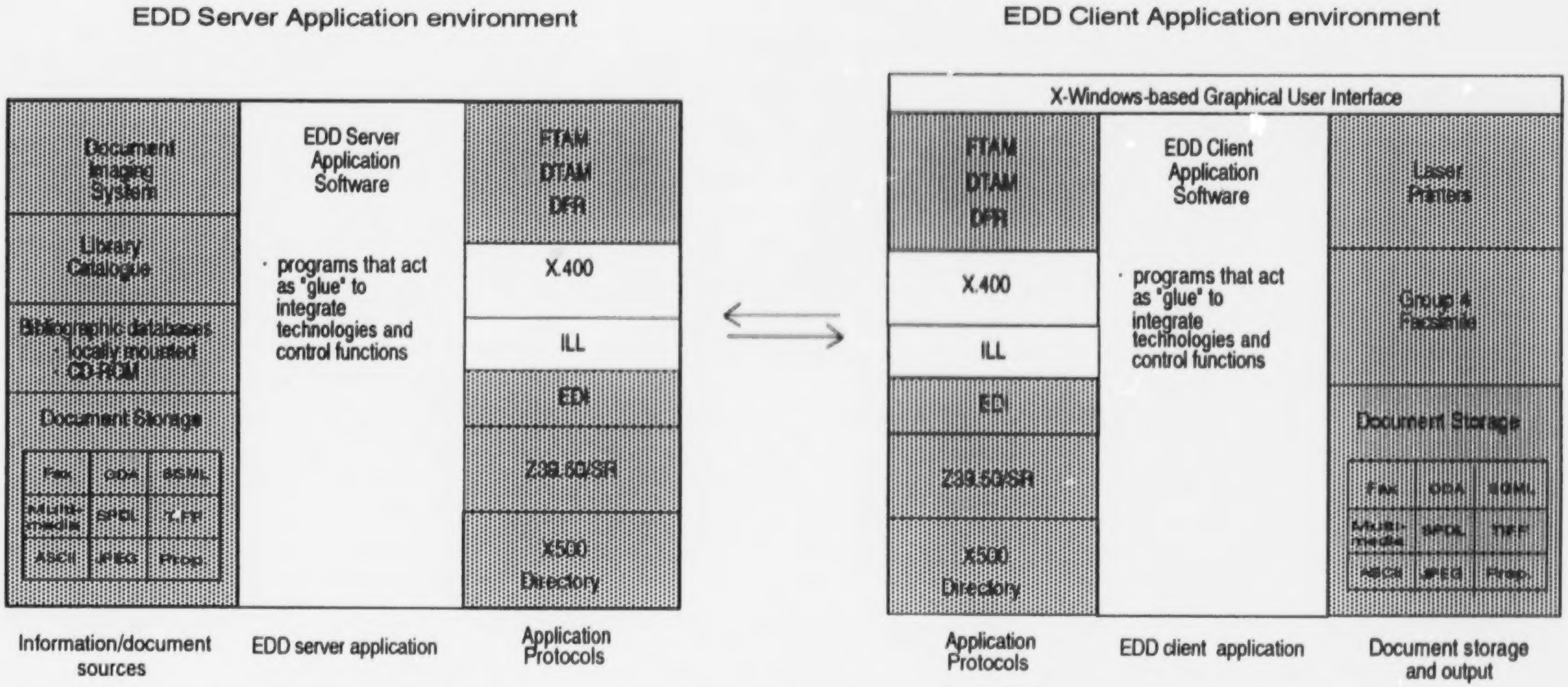
The steps are as follows:

Step 1 A document request is initiated from an EDD client workstation by interacting with, in this case, a GUI interface. The request contains all the necessary requesting information that was obtained during the access or selection stage of delivery. For example, the request would include:

- document identification information
- an indication of the required electronic form of the document
- an indication of the required document quality
- an indication of the required delivery service
- an indication of cost/royalty payment mechanism.

The EDD client workstation uses the ILL protocol to transmit the request. The request is sent over the high-speed WAN to the destined library.

Step 2/3 These steps represent messaging initiated by the library EDD server to obtain any further information from the EDD client to execute the request and to negotiate and obtain acceptance of the document's conditions of use, for example, copyright compliance. The messaging is performed using the ILL protocol and X.400


EDD Server Application environment
Document Imaging System
Library Catalogue
Bibliographic databases
- locally mounted
- CD-ROM
Document Storage
Fax
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Information/document sources
EDD server application
Application Protocols
EDD Client Application environment
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X500 Directory
EDD Client Application Software
· programs that act as "glue" to integrate technologies and control functions
Laser Printers
Group 4 Facsimile
Document Storage
Fax
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ASCII
JPEG
Prop.
Application Protocols
EDD client application
Document storage and output

Figure 4-18: Logical representation of elements active during document requesting, Unshaded areas are active, shaded areas are not.

4.2.2.3 Storage, retrieval, and transfer

In general, the final transfer of documents could be accomplished through the use of X.400, FTAM, DTAM or DFR, supported locally over high-speed LANs, and nationally and internationally over high-speed networks such as the planned NREN. Although some TCP/IP application protocols may used, the options available for document transfer from the OSI protocol suite are highlighted below.

FTAM, DFR or DTAM These approaches are appropriate for the synchronous transfer of documents as files. When using these methods, note that:

- a logical connection between the EDD client workstation and the EDD server must be established in order for transfer to occur
- the transfer will be performed synchronously
- document length is limited only by the storage capacities of the EDD client workstation and the EDD server.

X.400 This method is particularly useful for the transfer of documents as messages or parts of messages. Note that:

- since X.400 is a store-and-forward delivery mechanism, a logical connection between the EDD client workstation and the EDD server does not need to be established in order for transfer to occur, and
- the transfer will be performed asynchronously.

One drawback of X.400 is that document length is limited by the inherent X.400 content length limitation of 2 gigabytes, as well as by the physical storage limitations of X.400 message transfer agents.

ILL Protocol Existing transfer protocols and the ILL protocol have no provision for explicitly linking a transferred document to the request that triggered the transfer. Extensions need to be defined to support this capability.

One possible approach that eliminates the need to extend the various document transfer protocols is to allow the transfer of documents within the ILL protocol, as part of the ILL SHIPPED message. Depending on the implementation, the transfer could occur in a connection-oriented or store-and-forward fashion. The document length limitation will also be dependent on the implementation.

Group 4 fax As mentioned earlier, the *Group 4 fax* machine (with Group 3 compatibility) will continue to play a role in the future electronic document delivery environment. For paper-to-paper transmission of documents over a network, the use of fax machines is likely to remain a prominent transfer method because of its installed base, user familiarity, and ease of use.

Z39.50/SR The Z39.50/SR protocol, in addition to its ability to retrieve bibliographic information, can also be used to search and retrieve documents stored in document databases. The protocol allows searches on document attributes or on arbitrary strings to be performed and can be used to retrieve various types of document fragments according to the needs of the search application.

Figures 4-19 and 4-20 highlight the elements that are likely to be used during the *transfer stage* of electronic document delivery. Once again, shaded areas are not active. The specific steps are as follows:

Step 1 Once all the information required to complete the request is received by the server, an electronic copy of the document is retrieved from storage. For example, the document may be retrieved from an optical disc jukebox. It may also be supplied through the document imaging system—an on-the-fly option.

Step 2 The EDD server sends an electronic copy of the document in the form and quality requested via the delivery service requested. In Figure 4-18, this is done via one of FTAM, DTAM or DFR. In Figure 4-19, transfer is done through X.400 (a) and/or ILL (b) (other transfer options are not shown). The document, when received by the requesting library, may be stored or printed at the requesting workstation, or it may be sent to the local EDD server for storage and/or printing.

Step 3 The EDD server sends a monthly invoice to the requester, if applicable, formatted as an EDI message and transmitted via X.400. When the account is settled, the requesting library sends a notice of payment EDI message to the EDD server (not shown).

The configurations outlined in this chapter have illustrated the manner in which the document delivery process can be automated, solving the problem of delays and inefficiencies caused by the use of manual methods. First, fax and scanning systems are used for fast transmission of documents between ILL departments in the present and in a transition phase. Second, the document delivery process is integrated within a complete system that enables users to select, request, receive, and print documents from their local workstations. The use of a wide-spread, highly interconnected network to support the EDD application allows users to access documents from a variety of local and remote sources.

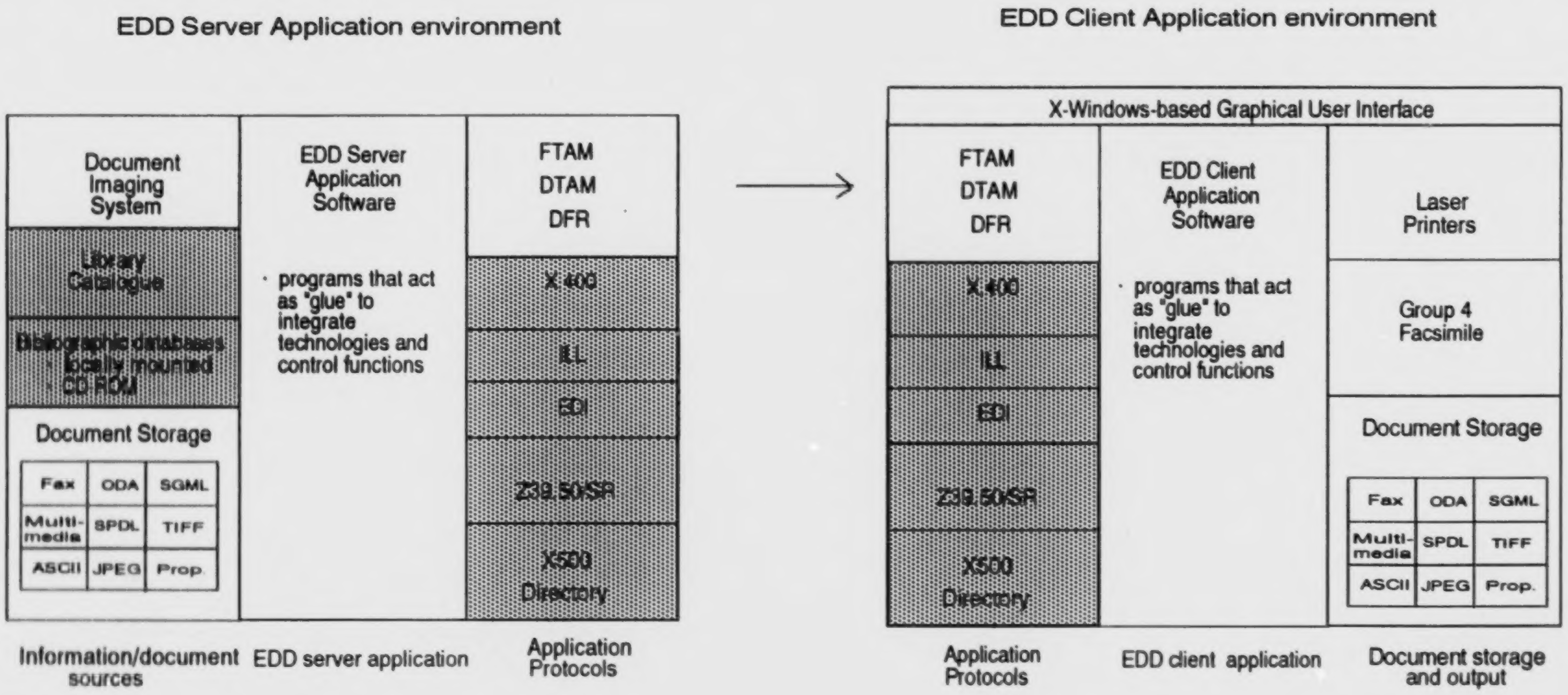
EDD Server Application environment
EDD Client Application environment
Document Imaging System
Library Catalogue
Bibliographic databases
· locally mounted
· CD-ROM
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop.
EDD Server Application Software
· programs that act as "glue" to integrate technologies and control functions
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Information/document sources
EDD server application
Application Protocols
X-Windows-based Graphical User Interface
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
EDD Client Application Software
· programs that act as "glue" to integrate technologies and control functions
Laser Printers
Group 4 Facsimile
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop.
Application Protocols
EDD client application
Document storage and output

Figure 4-19: Logical representation of elements active during storage, retrieval, and transfer -- File transfer example. Unshaded areas are active, shaded areas are not.

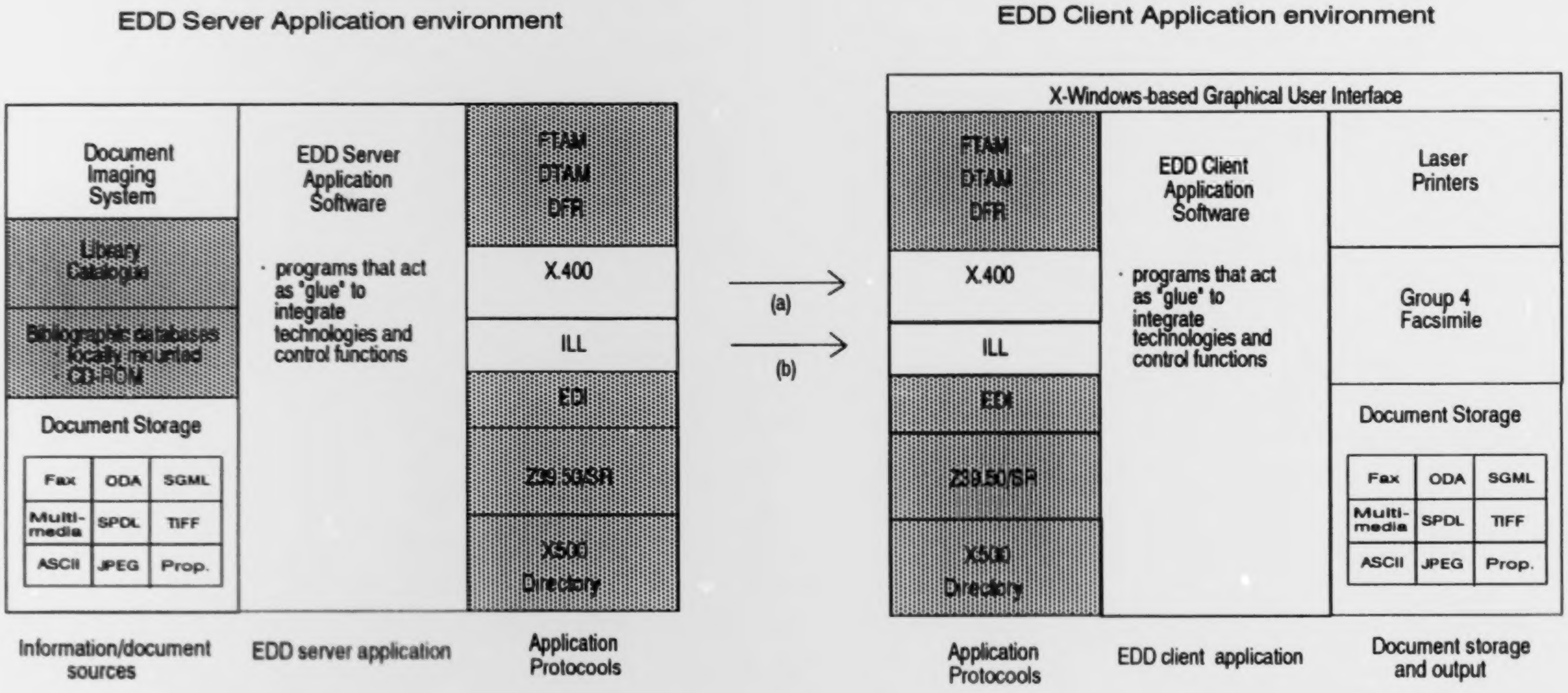
EDD Server Application environment
Document Imaging System
Library Catalogue
Bibliographic databases locally mounted CD-ROM
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop.
EDD Server Application Software
· programs that act as 'glue' to integrate technologies and control functions
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
Information/document sources
EDD server application
Application Protocools
(a)
(b)
EDD Client Application environment
X-Windows-based Graphical User Interface
FTAM
DTAM
DFR
X.400
ILL
EDI
Z39.50/SR
X500 Directory
EDD Client Application Software
· programs that act as 'glue' to integrate technologies and control functions
Laser Printers
Group 4 Facsimile
Document Storage
Fax
ODA
SGML
Multi-media
SPDL
TIFF
ASCII
JPEG
Prop.
Application Protocools
EDD client application
Document storage and output

Figure 4- 20: Logical representation of elements active during storage, retrieval, and transfer -- X.400 example [X.400 (a); X.400 and ILL (b)]. Unshaded areas are active, Unshaded areas are not.

5. ELECTRONIC DOCUMENT DELIVERY PROJECTS

Throughout the 1980's and early 1990's, a variety of experiments have been performed exploring a wide range of topics in the electronic storage, retrieval, and transmission of documents. These topics include, for example, the creation of CD-ROM image databases of journal articles and patent information, the transmission of documents by satellite, computer networks, and ISDN, as well as experiments with fully electronic journals, publishing systems, and SGML. An exhaustive survey of all such initiatives, however, would be beyond the scope and intention of this study. Instead, the following section will focus on some major projects that have attempted to automate the functions involved in the document delivery process.

It is clear that an effective electronic document delivery system will most likely incorporate all stages of the document delivery process—the selection, requesting, retrieval, and transmission of primary documents. While few working systems currently exist that integrate all of the above functions, there have been a number of projects that have attempted to: 1) automate previously non-automated stages of the document delivery process; 2) link one or more of these stages within a single system; and 3) utilize widely-interconnected computer networks as the telecommunications media for document delivery. This section will describe these projects, focusing on them as examples of development activities, rather attempting to create an up-to-date compendium of all such initiatives. Other activities, such as those involving standards like the ILL protocol and the X.500 directory, as well as activities of The Group on Electronic Document Interchange (GEDI), are also briefly noted.

The majority of the work presented deals with the delivery of journal articles and primarily of those in bit-mapped form. Other document representations, such as ODA or SGML, are not, as yet, widely used for document supply. Activities involving the use of regular fax machines over telephone lines to support document delivery in libraries, while increasingly common, are not discussed. Much information about the use of fax in libraries is available elsewhere (cf. Anand, 1987a; 1987b). One exception includes the use of digital networks as the transmission medium for fax images.

The remainder of the section is divided into four subsections: 1) electronic document conversion, storage and retrieval; 2) electronic document transmission; and 3) integrated electronic document delivery initiatives; 4) other activities.

5.1 Electronic document conversion, storage, and retrieval

A crucial component of electronic document delivery systems will be large databases of electronic documents that allow the automatic retrieval of primary documents. Because documents are not yet systematically represented in electronic format throughout all stages of their development, and because libraries have already accumulated large paper collections of materials, efforts to create document databases have focused primarily on the digitization of paper materials. Three principal examples in this area are the DOCDEL TRANSDOC project, the ADONIS project, and the National Agricultural Text Digitizing Project.

5.1.1 TRANSDOC and the CEC DOCDEL Programme

Worth noting is one of the earliest, but very extensive, initiatives investigating new information technologies—the Commission of the European Communities' (CEC) DOCDEL programme. The programme, which ran from 1984 to 1987, consisted of 10 projects that explored topics in four general areas: the electronic conversion of documents, the publication and delivery of electronic journals, the development of new electronic publishing systems, and electronic communication among scholars (Niels, 1989). Of particular interest to this study is the TRANSDOC project—an experiment in the creation, storage, and delivery of documents in electronic form.

TRANSDOC

The TRANSDOC project is considered to be "the world's first optical disc-based document delivery service for remote online users" (Mastroddi, 1988). It used early scanning and pre-CD-ROM technology to create a database of 50 journals in biomedicine containing a total of 105,000 pages. The system allowed users to submit requests for documents selected through the French bibliographic host, *Télésystème*, which could be subsequently printed out on a laser printer and sent through regular postal services (later developments enabled the documents to be sent via facsimile). System configuration consisted of an Alcatel Thomson Gigadisk with a capacity of 1 Gb for the storage of digital images, as well microfiche equipment that automatically selected and digitized microfiche on request. Document linkage and overall system management was performed by a Mini 6/Bull computer (Soule, 1988).

This early project showed that *en masse* document scanning and storage could be accomplished rapidly and reliably. It has spawned the development of other scanning initiatives, including the creation of a scanning office which was recently awarded a contract with the European Patent Office to convert 65,000,000 pages of patent documents to digital form (Niels, 1989).

5.1.2 The Adonis Project

The premier example of the electronic conversion and storage of documents is undeniably the ADONIS project, an experiment begun in 1986 by a consortium of publishers to test electronic methods of document delivery. As much is available elsewhere about ADONIS (see, for example, Campbell and Stern, 1990; David and Martin, 1989; Korowitz, 1990; Merry, 1988; Stern and Campbell, 1989; Stern and Compier, 1990), this section provides a general overview only. The main motivation of the ADONIS project was to determine whether the provision of journal articles in machine-readable form to document delivery centres and large libraries could make the document delivery process more efficient, thus allowing any savings gained to be passed on to the original copyright holders (Stern and Campbell, 1989). The four year trial yielded a set of 84 CD-ROM discs containing nearly 200,000 journal articles, and was considered successful enough for the consortium to introduce a commercial service in 1991 (IMT, 1990).

Work on the project initially began in the early 1980's with two studies to determine what types of materials were in highest in demand, and therefore would be most suitable for conversion into digital form (David and Martin, 1989). The studies, one in 1980 and one in 1983, monitored the document supply activities of the British Library Lending Division (now the BLDSC) and ascertained that the highest demand was for journals in the biomedical field that were less than three years old (Clarke, 1981). The technology necessary to convert and store the materials at the time, however, remained undeveloped or prohibitively expensive. Thus, the project did not fully begin until 1986 when scanning and CD-ROM technologies became readily available. A new consortium participated in the resurrected ADONIS project comprised of Blackwell Scientific Publications with participation by Elsevier Science Publishers, Pergamon Journals and Springer Verlag, Butterworth Scientific, Churchill Livingstone Medical Journals, C.V. Mosby, Munksgaard International Publishers, Georg Thieme Verlag, and John Wiley.

The trial

The materials chosen for the ADONIS project consisted of 224 biomedical journals published in 1987 and 1988. The production of the discs took place in a number of European countries. Copies of the journals were sent each week to a firm in Amsterdam where the articles, as well as editorials, letters, book reviews and reports of conferences, were indexed and assigned a unique ADONIS number. The journals were then pre-cut into sheets and sent to England for scanning, accompanied by indexing information in order to verify page numbers. The bit-mapped images and the index information were merged and stored on tape, then sent to Germany for final pressing onto CD-ROMs. The throughput time for the entire conversion process was approximately four weeks (Stern and Campbell, 1989).

The Adonis system was tested in a variety of environments in ten different countries including libraries and document centres in the U.K., Sweden, Germany, the Netherlands, France, Spain, the U.S., Mexico, Australia, and Japan. Each participant paid a token subscription fee, provided support staff, as well as paid a royalty charge for any materials printed in excess of 10,000 copies. Configuration of the workstations consisted generally of a 640K IBM PC (or compatible) with a 30 MB hard drive, a high resolution monitor, a CD-ROM drive, a laser printer, as well as interface cards to link the peripherals and perform compression/decompression of the image files. Search software, initially developed at the British Library and MC2, went through various modifications and improvements throughout the trial period (Stern and Compier, 1990). A CD-ROM jukebox was added to the system in later stages of the trial to more efficiently handle the increasing number of discs, thereby eliminating the need to manually select discs.

When a request was received, a known-item search would be performed on an index housed on the microcomputer's hard drive. The documents were then retrieved from the appropriate optical disc and sent directly to a laser printer.

Advantages and future needs

Although the project was plagued with many problems, it provided some advantages over manual methods (David and Martin, 1989; Stern and Campbell, 1989):

- the system has the potential to reduce storage costs. For example, the 200 plus ADONIS journals require 36 feet of shelving space in paper form, while the equivalent journals on CD-ROM require six inches—a reduction to 1/150th of the original space

- the system can reduce binding, conservation, and staff costs

- monetary savings realized through reductions of storage, binding, and staff time can be applied to copyright payments, more accurately reflecting the use of materials

- per article fee which includes a royalty payment may avoid the ambiguities of current copyright legislation

While the trial suggests that an electronic document delivery system based on optical technology is a viable alternative to photocopy-based systems, a number of modifications would make the systems more efficient (Barden, 1990; Korowitz, 1990; Stern and Campbell, 1989):

- a fully functional delivery service will require more than the 200 journals available in the ADONIS system; large scale conversion of scholarly journals will be needed

- the number of publishers involved will have to increase in order to obtain a broader coverage of materials

- subject access will need to be added to stimulate use of the system. Increased demand will help justify the relative high expense of the system.

- multitasking is needed to allow simultaneous searching and printing

- direct linkage of the ADONIS system to an electronic mail system would allow automatic processing of incoming electronic requests (see DOCMATCH below)

- dedicate an ADONIS workstation to act as a server in a network environment to enable requesting and delivery of documents directly to end-user workstations

The ADONIS commercial service

The overall results of the ADONIS field trial were successful enough to encourage the consortium to offer ADONIS as a commercial service. The ADONIS Board in charge of the system decided to introduce a fully operational service in January, 1991 (Korowitz, 1990). The commercial version will contain 437 journals selected according to their use by pharmaceutical companies. Initially, 15,000 pages will be stored on disc, to be eventually increased to 50,000. An annual fee will be imposed for use of the software, discs, and service, while a per article licence fee will be payable to the publishers.

5.1.3 National Agricultural Text Digitizing Project

Another major project with the goal of creating an image database is the National Agricultural Text Digitizing Project (NATDP) at the National Agricultural Library (NAL) in the U.S. The purpose of the project, begun initially in 1986, was to "test the feasibility, costs, and effectiveness of newly emerging technologies for capturing page-images, providing access to their content, and disseminating them" (Andre, Eaton, and Zidar, 1988:62). The overall project consists of three phases, outlined below.

Phase I

The first phase of the project, now complete, tested the effectiveness of a workstation—a microcomputer, flatbed scanner, optical character recognition (OCR) software, and automatic indexing software—to create a fully indexed image database. Non-copyright restricted books, journal articles, pamphlets, dissertations, and bibliographies on aquaculture were selected for conversion. The documents were scanned, checked for quality, and run through OCR software and turned into ASCII code. This code, once corrected for errors, was then submitted to indexing software to create indexes for the images. Pointers linked the index entry with the appropriate page images.

This combination of text and images provided both the capability for information retrieval as well as the advantage of viewing the "original" scanned image of a document. The final product was pressed onto CD-ROM to create a 4000 page image database. Two other discs were produced during this phase containing, respectively: 1) documents published by the Consultative Group for International Agricultural Research (CGIAR); and 2) NAL's collection on the herbicide, Agent Orange (Andre, Eaton, and Zidar, 1989).

The three discs were field tested by 44 land-grant libraries from 1988-1990. Other goals of Phase I were to evaluate various retrieval software packages to be used with the discs.

Phase II

The second phase of the project involves refinement of the initial system, the testing of hardware and software, as well as the creation of three additional CD-ROMs to contain 11,000 pages of documents issued by the Canadian government on acid rain. The discs were to be distributed to the participating land grant libraries in March of 1990 (McCone and Starr, 1990).

Phase III

Phase III, now in progress, will investigate the transmission of agricultural literature both on-the-fly and from the CD-ROM databases developed in Phases I and II to remote sites through the *Internet*. This phase will be described in more detail in 4.2.3 below.

5.2 Electronic document transmission

One of the least automated functions in the document delivery process—the transfer of primary documents—has recently been the focus of a number of trials and experiments. Although digitized images, in the form of standard facsimile transmissions, are used increasingly to automate the final delivery of documents to libraries, there have been interesting developments in this area. These developments involve: 1) the use of established computer networks, such as the *Internet*, as the transmission medium for standard fax images; 2) the use of a microcomputer and flatbed scanner, instead of fax, to digitize and transmit documents on-the-fly over a research network; and 3) the transmission of images created both on-the-fly and previously stored on CD-ROM over research networks and ISDN systems. Projects examining these forms of transmission are described below.

5.2.1 Network Fax Project

The Network Fax Project is an initiative to examine the transmission of facsimile images over the *Internet*. The focus of the project, managed by the Instruction and Research Computer Center (IRCC) of the Ohio State University and funded by OARnet, CICNet, and the IRCC, will be to research and build an *Internet*/Fax gateway for document transmission (OSU, 1990).

The system consists of a Group 3 fax machine, a microcomputer equipped with a hard drive, as well as fax and Ethernet interface cards. In operation, the system scans and stores documents on the microcomputer's hard drive and, using FTP, the G3 fax image is sent to a similarly equipped remote microcomputer for temporary storage. For final printing at the remote site, the image is sent back through a fax machine.

Advantages of the system include:

- the use of the *Internet* at no direct cost to the user
- the ability to avoid the problem of busy fax machines because the image is intercepted by a microcomputer and stored
- the network transfer operates in the background allowing continual use of the fax machine.

One disadvantage of the system, however, is that, while image transfer through the *Internet* portion is virtually instantaneous, end-to-end transmission speed is limited by the speed of the fax machine, and a telephone connection between the fax machine and the local microcomputer. Further, an extra step is still needed to photocopy a document before it is faxed. Future developments of the Network Fax Project include the use of G4 fax machines, and investigations of the use of scanners for image production.

5.2.2 RLG's Ariel

An advance on the above theme is the Ariel document delivery system developed by Research Library Group (RLG). The Ariel system is designed to deliver scanned, rather than faxed, images of documents over the *Internet*, as well as other computer networks. Also known as the Document Transmission Workstation, the system consists of an IBM AT (or compatible) as a central processor, an HP ScanJet Plus scanner for the production of high-quality images (300 dpi), and an HP LaserJet II printer to produce output on bond paper (RLG, 1991). Menu-driven application software, developed by RLG, integrates and monitors workstation activities.

Ariel can be used in ILL departments and other document supply centres as a rapid and convenient form of "on-the-fly" electronic document delivery—the simultaneous scanning and transmission of a document on demand. The system can handle text, photos, charts, formulae, and tables, as well as any other material that can be scanned. In operation, staff scan the requested documents, which are then compressed by the system and stored for transmission over a computer network. At the receiving end, a microcomputer accepts the image and makes a laser-quality printout on bond paper. Currently, Ariel runs on Ethernet and *Internet*, with Token Ring and SprintNet connectivity on the horizon.

The workstation performs a function similar to facsimile, but is designed to be faster, more reliable, and less expensive to use than fax machines. Advantages of the Ariel workstation include the:

- production of images of much greater resolution than fax
- production of output on regular bond paper
- use of off-the-shelf hardware
- availability of the workstation for other uses—word processing desktop publishing, scanning, printing—when not used as a transmission workstation
- ability to scan documents directly without the need to first photocopy the original
- ability to use the *Internet*, a highly-interconnected computer network, that currently does not incur direct charges to the user

- capability for fast printing enabled by the PC/printer interface.

The Ariel system was beta-tested in six university libraries in the U.S.: the University of Pennsylvania, the University of Michigan, Colorado State University, Dartmouth College, and the University of California at Berkeley and Davis. Yale Medical and Engineering Information, Inc. will soon be beta test sites. A production version of Ariel was released in September, 1991.

5.2.3 The NCSU and NAL Joint Project

Another project that focuses on document transmission is a joint venture by the North Carolina State University (NCSU) and the National Agricultural Library (NAL) to deliver digital images over the *Internet*. As Phase III of the National Agricultural Text Digitizing Project (discussed above in 4.1.3), the project will investigate various aspects of transmitting scanned images of agricultural documents from the NAL to libraries, research areas, researchers' desks, agricultural research stations and extension offices of a number of land grant universities (NCSU, 1991).

Specifically, the project will examine (McCone and Starr, 1990:36):

- the use of standard, widely-supported image formats for scanned page images
- the use of widely available computers for display and manipulation of the page images
- the efficiency, speed, and ease-of-use of the national *Internet* and Local area networks for distributing page images
- the administrative arrangements and structures required for soliciting requests and satisfying them through electronic distribution.

Operation
The medium for the submission of requests to the NAL is electronic mail via the *Internet*, BITNET, and other computer networks, as well as the future possibility of submission through the OCLC ILL Subsystem. Three bibliographic sources are preferred to ensure that requests are actually held by the NAL: 1) Aquaculture CD-ROM; 2) AGRICOLA; and 3) OCLC records with NAL as a location (McCone and Starr, 1990).

In response to the requests, documents are scanned on-the-fly, or retrieved from the four CD-ROMs created in Phase I and II of the NATDP project. The images are then transferred to the requesting library by FTP (TCP/IP File Transfer Protocol) through SURAnet (Southeastern Universities Research Association Network), an *Internet* regional network.

The images are not sent directly to end-users' workstations, but intercepted by NCSU ILL staff, who distribute the materials to the requestor. Three alternative distribution methods are available (McCone and Starr, 1990):

- ***direct electronic delivery*** in which the requestor extracts the electronic copy from the NCSU VAX
- ***intermediate electronic delivery*** in which the requestor first reviews the images onscreen at the library, then obtains a copy on floppy disc if an electronic form is required
- ***print copy delivery*** where library staff review the image and print a 300 dpi paper copy for the physical delivery to the requestor.

Copyright considerations

Problems associated with copyright will be avoided in the NCSU/NAL joint project by transmitting and receiving only those documents that have not been copyrighted, or that fall under the fair-use exemption. Because the copyright issue is such a serious obstacle to any large-scale implementation of an electronic document delivery system, the project will also undertake extensive research into copyright as it pertains to the transmission of digitized documents. Negotiations with academic publishers, carried out by the NAL, will also hopefully allow copyright clearance of the distribution of copyrighted literature in electronic form (NCSU, 1991).

Current status

An initial pilot project established a test link between the NAL and the NCSU libraries and successfully transmitted images between computers at the two sites (Casorso, 1991a). An "expanded, full-scale implementation" test of the pilot system is taking place during the 1990-1992 period (NCSU, 1991:1). For the expanded test, fourteen land-grant universities have received workstations, consisting of off-the-shelf, graphics-capable microcomputers, scanners, and laser printers, which are connected to the *Internet*. The fourteen libraries are located such that almost every regional network of the *Internet* is represented. The libraries are able to create and exchange digital images of agricultural documents in support of interlibrary loan. Project participants expect to integrate the system within the ILL departments' and be in full production mode by September 1, 1991 (Casorso, 1991b).

5.2.4 FOUDRE and the INIST document delivery system

In France, two electronic document delivery pilot projects underway are FOUDRE (*Fou*rniture de *d*ocuments sur *r*eseau *e*lectronique) initiated by *Ministrè de l'Educations Nationale*, and a system under development by INIST (*Institut de l'Information Scientifique et Technique*). Interesting aspects of these projects include the use of ISDN as the transmission medium, and the creation of an image database in an *a posteriori* fashion. These projects are described briefly below.

FOUDRE

The FOUDRE pilot project was begun in 1988 as a joint project between *Ministrè de l'Educations Nationale* and France-Telecom (Deschamps, 1991). The objective of the project is to develop a fully automatic system for delivering periodical articles between libraries using NUMERIS—the recently inaugurated French ISDN. The FOUDRE project has taken an approach slightly different from those previously discussed. The main thrust of the project is to use a microcomputer/scanner/laser printer configuration to deliver documents on demand, as with Ariel or the NCSU/NAL project. However, an image database will also be created simultaneously by storing each image as it is scanned. In this way, FOUDRE takes an *a posteriori* approach to database creation, rather than an *a priori* approach, such as that used in the ADONIS and NATDP projects. The researchers reasoned that, as it would be extremely difficult to predict the nature of the requests, systematic scanning and storage of all articles would not be practical.

In operation, every document requested through ILL, or by email directly from end-users, will be scanned and stored on an *Optical Numerical Disk* (DON). Each lending library will have a list identifying the stored articles so that subsequent requests for the articles can be filled automatically from the database. FOUDRE will be interfaced with the indigenous PEB (ILL) system to streamline the handling of requests. The requestor's workstation will consist of a microcomputer and laser printer connected to NUMERIS. Group 4 facsimile machines are also envisioned as future receiving stations.

The FOUDRE system will be tested for the first six months of 1991 with three lending libraries and nine borrowing libraries. Subsequent evaluation will focus on costs, service, hardware and software, with special attention to effects upon ILL workflow.

INIST document delivery system

Institut de l'Information Scientifique et Technique (INIST) was established in 1988 as a new administrative organization consisting of the former document supply centres, *Centre de Documentations Scientifique et Technique*, and *Centre de Documentations Sciences Humaines* (CDSH). Like FOUDRE, the INIST electronic document delivery system will utilize NUMERIS, as well as the Minitel terminals located in many French homes.

In early 1990, INIST began a programme to do a systematic conversion of 2000 journal titles into bit-map form. As each issue arrives at INIST, it is catalogued at the component part level to establish links with the page images, and send daily to JOUVE, a French scanning company. The resulting information is then pressed onto CD-ROM discs. System configuration consists of a microcomputer, a jukebox, and a laser printer. The actual delivery service was introduced in early 1991.

Requests are received directly from users "automatically" through database hosts (QUESTEL and ESA), or by typing the bibliographic information directly to a terminal. The request system is linked to the INIST catalogue, automatically producing a request workform. Copies of articles can be sent to users in one of two ways: 1) local printing on a high-speed laser printer for transfer through the post; or 2) sent to a Group 4 fax machine which, in turn, transmits the document through NUMERIS to remote stations in research centres.

Continuation of the programme will be dependant upon an analysis of the technical system and costs. INIST has admitted that it has "made a bet" when investing in the system that problems, such as the impact upon authors and publishers, as well as copyright, will be solved allowing the programme to continue unimpeded (Lupovici, 1990:5).

5.3 Integrated electronic document delivery initiatives

The examples presented thus far have concentrated on the automation of individual elements of the document delivery process—storing, retrieving, and transmitting documents in electronic form—without a great degree of integration and linkage among those elements. The following systems, on the other hand, are examples of projects designed to automate and interlink two or more of the stages in the document delivery process. The first, DOCMATCH, is an attempt to integrate the requesting and retrieval stages such that an incoming request can be automatically processed, and the appropriate document retrieved from an image database. The second, Project QUARTET, uses the database developed in the ADONIS project to develop a system that automates the requesting, retrieval, and transfer stages of document delivery. The third project is a wide-ranging plan to develop a fully electronic library that will allow users to select, request, and receive documents directly from their personal workstations. These projects are outlined in more detail below.

5.3.1 DOCMATCH

The DOCMATCH project, a CEC-funded project carried out at the BLDSC, was an attempt to take the automation of the document delivery process one step beyond ADONIS. Whereas ADONIS's purpose was to create an electronic database of biomedical journal articles, DOCMATCH's goal was to link incoming requests for those articles directly to the ADONIS workstation for automatic processing and retrieval by end-users (Ayres, *et al*, 1990). Many requests arriving at the BLDSC are in machine-readable form, such as those from MEDLINE, DIALOG, and ARTTEL. The lack of linkage between these automated requesting systems and the ADONIS workstation requires staff to re-key citation information causing additional staff effort, delays in the process, as well as the potential for transcription errors.

To avoid re-keying information already in electronic form, the DOCMATCH project developed a method by which requests arriving for database hosts could be processed and automatically submitted to ADONIS. The DOCMATCH software created a Universal Standard Bibliographic Code (USBC) based on the bibliographic information contained in an incoming request. This code was then matched against an index containing USBCs for all ADONIS articles. If a match was found, the USBC, as well as customer information, were submitted to ADONIS allowing a print version of the article to be automatically produced (Ayres, *et al*, 1990).

The success of the DOCMATCH system in finding the correct articles depended heavily upon the richness and consistency of the bibliographic information contained in the original electronic request. For example, while an almost 100 percent success rate was found in matching requests from DIALOG, the success rate for requests arriving from other sources, such as ARTTEL, was much less. This difference is due to the fact that database hosts, such as DIALOG, contain a higher quality and quantity of bibliographic information and were thus more amenable to automatic processing than other systems. In fact, the experimentors decided not to use requests from ARTTEL because of inherent poor quality and vagaries in format (Ayres, *et al*, 1990).

While the layout of citation information follows a relatively standard pattern—title, author, journal name, journal number, page, year of publication—even slight variations can confuse software and defeat automatic extraction. Such variations can occur not only *within* a single requesting system, but also *across* disparate systems. This wide range of formats and systems makes designing software to do the extraction a very difficult task. The problem is further exacerbated by the fact that many bibliographic databases lack clear field tags that explicitly identify specific bibliographic elements. If bibliographic databases used explicit tags based on a standard format, such as SGML, automatic extraction of bibliographic information would be considerably more efficient (Ayres, *et al*, 1990).

The findings of the DOCMATCH project suggest that the requesting portion of the document delivery process can be linked with retrieval from electronic storage. It is also apparent, however, that a number of obstacles must be overcome before a fully automated system can be developed. For example, a standardized request format (such as that specified in the ILL protocol) will be needed to effectively handle the large number of requesting systems and bibliographic formats with which a large document source must deal. A standardized request format, as well as explicit field tagging (such as with SGML) will make automatic extraction, and therefore document retrieval more effective.

5.3.2 Project QUARTET

Project QUARTET, completed in 1989, represents an attempt to create a more integrated document delivery system that incorporates document requesting, retrieval and transfer. The overall objective of QUARTET, funded by the British Library Research and Development Department, was "to investigate the applications of new technology to the improvement of communications within the U.K. academic research community" (Tuck, 1989:94). This broad scope included projects such as the BLEND experiments with computer conferencing, as well as the University College London investigations of the electronic document. Most recently, Project QUARTET focused on creating an automated document requesting and transmission system using the ADONIS journal article database.

In creating a prototype system, Project QUARTET followed an approach similar to that used in this study; that is, that an effective document delivery system would integrate all the functions extant in the overall document delivery process—bibliographic selection, request submission, document retrieval, and document transfer (Tuck, 1989). A prototype system was developed that divided the various tasks between three separate computers creating modules that acted as input server, database manager, and output server. The modules were linked together via an Ethernet LAN.

Input server The function of input server, supported on a SUN 3/50 Unix machine, was to handle the incoming requests received through electronic mail. While the email application was based on JANET's Grey Book standard for electronic mail in the initial prototype, a mature system would most likely use the X.400 MHS standard to gain the enhanced connectivity associated with this OSI protocol (Tuck, 1989). Tuck (1988) suggests that electronic mail is the most logical choice for sending requests as it eliminates the need to re-key request information.

When a request is received by the input server, staff record and process the request by checking the validity of the requestor in a client account list, as well as the availability of the document. While the initial prototype required direct intervention by staff to process a request, further work has been done to fully automate this process. One suggested approach is to use a system similar to that used in the DOCMATCH project, discussed above. A simple request management prototype has been developed by QUARTET to support the automated process of requests received by electronic mail (Tuck, 1989).

The input server also supported the searching of the ADONIS index allowing the index to be searched independently of document retrieval. In addition, the input server was responsible for coordinating the whole system through Remote Procedure Calls.

Database PC The function of the database PC was to search and retrieve the specific articles matching the requests. The database PC was basically an ADONIS workstation as described above in Section 5.1.2 with the addition of a collection of title pages of QUARTET research papers scanned and stored on the Database PC's hard disk. In 1989, the group expected to incorporate a CD-ROM jukebox to handle the large number of ADONIS discs.

Output server The output server is designed to handle the distribution of the electronic document. Theoretically, it has the capability to transmit the document through a number of channels, including Group 3 facsimile, Group 4 facsimile, or directly to a local laser printer. The demonstration system used a microcomputer and G3 fax card to send documents to a standard fax machine. To receive the electronic documents, the user's microcomputer was equipped with a fax card with a laser printer to print regular paper copies.

The prototype system was demonstrated at the Online Exhibition at Olympia, London, in 1988. A test of the system was planned to take place between the Whittington Hospital Library, and its parent institution, the Bloomsbury Science Library and University College London, in which users would be allowed to directly access the QUARTET system (Clarke and Tuck, 1988).

5.3.3 The Mercury Project at Carnegie Mellon University

An ambitious project underway to create an electronic library that would include electronic document delivery functions is the Mercury Electronic Library at Carnegie Mellon University (CMU). The Mercury system is currently under development and is designed to "deliver to the scholar at the workstation all the information that is needed for research" (OCLC Annual Review, 1989:38). This information includes print materials, machine-readable files, hypertext databases, online public databases, online library catalogues, and personal databases. Equipment, funds, and machine readable-files are supplied by Digital Equipment Corporation, the Applied Information Technology Research Center, the American Association for Artificial Intelligence, the Institutes of Electrical and Electronics Engineers, and the Association for Computing Machinery.

The purpose of the Mercury Electronic Library will be threefold (Arms and Holzhauser, 1988):

- to demonstrate that a large-scale distributed library can be built with current technology
- to act as a laboratory for the study of electronic information management
- to act as a functional electronic library for computer science research

The basic configuration of the Mercury library will be high-end workstations, using a software environment based on X Windows, connected to a high-speed network. A workstation will allow users to locate documents, retrieve them from the computers where they are located, and deliver them directly to users for onscreen display (IRLA, 1989). The Association for Computing Machinery has agreed to provide machine-readable versions of four of the most important journals in Computer Science: *Computing Reviews* (10 years), *Collected Algorithms* (25 Years), *Communications* (2 years), and *Guide to Computing Literature* (10 years). In addition, Mercury will also augment scholarly communication by merging published information with valuable, but unpublished, information available on discipline-related bulletin boards (Arms and Holzhauser, 1988).

Among a number of problems areas for which the Mercury initiative will provide a testbed are:

- ***computer systems***, including the development of distributed servers, textual and graphical databases, automated reference assistance, and nationwide file systems
- ***information capture***, including investigations of markup languages, digital scanning and optical character recognition, automatic indexing, and storage methods
- ***information delivery***, including studies of user interfaces, context-sensitive help, and user behaviour
- ***economics and management***, such as incentives to authors and publishers, intellectual property rights, cost distribution and payment models, and comparative costs of delivery.

5.4 Other activities

Colorado Association of Research Libraries' UnCover2
The Colorado Association of Research Libraries (CARL) has recently announced UnCover2, an electronic document delivery service that accompanies the original UnCover journal article citation database (AT/L, 1991). Uncover2 allows users to perform a search, view article delivery information, place an order, and make payments for documents, all from terminals located in libraries, homes, or offices. The documents ordered are scanned or faxed, and sent to fax machines designated by the users. In some cases, where approved by publishers, CARL retains the image of a requested document for later re-use. The system is available through dial-up access, or through the U.S. *Internet.*

CARL is negotiating with the Copyright Clearance Centre in the U.S. to establish appropriate copyright fees for journal articles. These fees currently stand at an average of $3.50 per article, with an additional CARL service charge of $6.50 (AT/L, 1991).

The Group on Electronic Document Interchange (GEDI)
Representatives of institutions in Europe and North America met in October 1990 to discuss the formation of a working group, called GEDI, to develop coordinated mechanisms to transmit documents electronically. Participants in the discussion included the British Library Document Supply (United Kingdom), Pica Centre for Library Automation (Netherlands), the Ministry of Education Directorate of Academic Libraries (France), Questel (France), Telesystemes (France), the University and Technical Information Library, Hanover (Germany), OCLC (USA) and Research Libraries Group (RLG) (USA). In recognition of the need for coordinated efforts in this area, the participants agreed to form the Group on Electronic Document Interchange or GEDI.

GEDI's focus is to develop mechanisms to transmit a document electronically between libraries by using existing standards and technologies. The group hopes to facilitate electronic access to source documents whether they exist as paper documents or in full-text databases. Scanning technology will be used to convert the text from paper documents into an electronic format that can be transmitted across network connections. The demand for this functionality has grown with the increased use of citation databases.

The group has recognized that the technology to support this type of document interchange is currently available. Their goal is to develop a common framework for the exchange of documents that can be implemented in the near term and is compatible with the various networks currently used by libraries in Europe and North America to access electronic databases. A report which describes GEDI's objectives and activities will be available from its members in the summer of 1991.

The ILL protocol

The ILL protocol was approved in April, 1991, as an International Standard by the International Standards Organization (ISO). Implementations are currently being developed by institutions and software vendors in North America and Europe. The National Library of Canada, the British Library Document Supply Centre (BLDSC) and the Library of Congress are involved in a joint ILL demonstration project. Libraries in Great Britain, the Netherlands and France are involved in a project to provide experience with the ILL protocol and an information retrieval protocol. Further ILL activity includes the creation of the International Forum on Open Bibliographic Systems (IFBOS) which is composed of institutions from Canada, the United States, Great Britain, and Europe to examine the issues relating to the use of protocols for international bibliographic communication.

One of the factors that is likely to delay the widespread implementation of the ILL protocol in North America is the fact that most of the major bibliographic utilities, such as OCLC and RLG, already have ILL messaging services, generally using proprietary protocols and data structures. Many will be reluctant to change to the new standard when the systems they already have work reasonably well.

The X.500 Directory

Several X.500 pilot projects are underway in North America and Europe in close collaboration with ISO and CCITT. These projects have provided feedback to the standards bodies to ensure that the final standard will meet industry requirements. Among these pilot projects are FOX (Field Operational X.500) and PSI White Pages in the Internet; CDNnet white pages and National Library of Canada Directory Advisory Group in Canada; PARADISE (a sub-project of the broader COSINE project), U.K. Academic Community Directory Service Pilot, and U.K. Communications Research Group prototype X.500 services (cf. Planka, 1990) in Europe.

Z39.50/SR

One significant development in the use of Z39.50/SR is the Wide Area Information Server (WAIS) Interface Protocol being developed by Thinking Machines Corporation and Dow Jones & Company Inc. The initial implementation will provide a protocol for the DowQuest database service provided by Dow Jones News Retrieval (Thinking Machines Corporation, 1990). Another development is the UCB Network Information Server Project by the University of California at Berkeley. UCB students, faculty and staff will be able to search for and retrieve information on a wide variety of subjects using the campus network and an information server (Kunze, 1990).

The projects outlined in this section provide examples of previous and ongoing work to automate and/or link one or more of the functions involved in the document delivery process. While few working systems currently integrate all functions, each project described represent beginning, but necessary, experiments on the road to the development of fully integrated electronic delivery systems.

6. ISSUES IN ELECTRONIC DOCUMENT DELIVERY

The shift from paper-based information systems to integrated electronic document delivery systems will have a strong impact upon established patterns and processes associated with information production, access, and distribution. While there are many issues that will inevitably arise during this transition, the two most salient are intellectual property rights in the electronic environment and the impact upon the scholarly communication system. This chapter provides a brief overview of these two major issues, as well as a number of other important issues such as document delivery in developing nations, electronic document integrity, bibliographic control, and the need for electronic document archives.

6.1 Intellectual property rights

One of the largest issues in electronic document delivery is that of intellectual property rights. The existing body of laws governing intellectual property rights, such as patents, trade secrets, competition, and copyright, has not kept pace with rapid advances in information technology; basic assumptions that were true in a paper-based environment are no longer true in an electronic environment. Of particular interest to libraries are those intellectual property laws protecting original works of authorship, known as *copyright* laws. The seriousness of the issue is such that it has prompted one writer to state that "the copyright system has become a nightmare: issues such as acquisition of rights for use of material, fair use, and even determination of the copyright status of materials has effectively paralyzed progress in innovations related to dissemination of scholarly information" (Lynch, 1991b:23).

The issue of copyright in the electronic environment is extremely complex and multifaceted. An exhaustive discussion of all its aspects would require a major study in itself and is well beyond the scope of this paper. Instead, only a brief overview of the major issues of copyright is provided, focussing on those that have most impact upon electronic document delivery. The discussion, furthermore, deals largely with American copyright law which has undergone many changes in recent years in an attempt to cope with the new electronic environment and is therefore most up to date. For more detailed information about the many issues surrounding copyright in the electronic environment, please see Oakley (1989, 1990), Miller and Blumenthal (1986), Gilbert (1990) and Avram (1989), among others.

6.1.1 The concept of copyright

Historically, copyright was based on the premise that individuals should be compensated for their labour—that authors, artists, scientists, and other creators of intellectual "property", should be protected from the unauthorized copying of their work (Miller and Blumenthal, 1986). More recently, copyright is conceptualized as the mechanism by which a steady supply of ideas can be ensured, although its exact basis varies from country to country. Because ideas are intangible, however, copyright protection applies to the *tangible* expression of ideas in permanently fixed forms, such as film, sound recordings, and print materials, rather than the ideas or information themselves. The notion of tangibility has formed the basis for compensating authors for particular expressions of ideas because the relative value of the ideas could be determined by the number of copies made of a fixed form. For example, the greater the value of the information contained in a book, the more copies of it are made and sold. Because of the making and copying of fixed forms has traditionally been a specialized and time-consuming process, the number of copies of a work made has been easy to monitor and control. Thus, the copyright holder could maintain relative control over the copying of his or her work, and receive due compensation.

The assumption of easily controlled copies is no longer valid, however, with the advent of modern information technologies. Photocopiers, for example, were one of the first technologies to put pressure on the copyright system because they allowed multiple copies to be made quickly, inexpensively and effortlessly. The ease with which copies could be made with these machines diminished the control over the reproduction of a work, the basis for compensation. The balance of the scale was thus tipped away from the information producer toward the information user who could make as many copies of a work as he or she wished.

In an attempt to redress this imbalance, the concept of *fair use*, or *fair dealing* as it is known in the U.K. and Canada, was adopted to attempt to control unbridled copying. Essentially, fair use allows users to make *one* copy of a portion of a document, such as a journal article, provided it is for research or educational use. The copying of complete works, such as an entire issue of a journal or an entire book, or the making of multiple copies of selected portions, are violations of copyright. Fair use is an attempt to allow the free flow of information to users, while protecting copyright holders by prohibiting the excessive copying that could undermine potential markets.

With electronic and digital technologies, such as personal computers, optical storage technology, and computer networks, the problem of monitoring and controlling copies becomes even more acute, and the application of current copyright law more problematic. Electronic information exists in a form that can be reproduced with even greater speed and ease than what is currently enabled by photocopy machines. Furthermore, in a networked environment, information in electronic form can be transferred from user to user, or machine to machine "totally beyond the control, or the knowledge, of any third party" (Miller and Blumenthal, 1986:229). The control of copies and the basis of compensation breaks down completely with such media. The balance has been tilted to such an extent toward the information user with electronic information that producers are seeking alternate means for compensation for information shared by users (Avram, 1989). These alternate methods include, for example, pricing schedules that attempt to anticipate the rate of copying, government imposition of compulsory royalties, and taxation of blank media.

6.1.2 Copyright and document delivery

In current paper-based document delivery schemes, considerable attention is already paid to copyright because of the extensive use made of photocopies. Library exemptions, which exist in most bodies of copyright law as a result of strong lobbying by library communities, permit libraries to engage in limited types of photocopying under certain conditions. Sections of the U.S. copyright law concerning interlibrary loan, for example, allow copies to be made from documents located in other library collections for local users provided that: 1) the copy is a single copy of a single article, or of a small portion of a larger work; 2) the copy will become the property of the user; and 3) the library has no indication that the material will be used for purposes other than education or research (Oakley, 1989).

Other related restrictions on ILL photocopying also apply. First, libraries may not make multiple copies of a single work, whether the copies are made at one time, or over a longer period. This restriction includes not only making multiple copies of a single article for one user, but also making copies of a single article for many individual users over time. A second restriction is that libraries cannot request photocopies of materials from other libraries in such quantities as to substitute for subscriptions or purchases (Boucher, 1984).

Electronic document delivery

Although the extent of photocopy use in current paper-based document delivery systems necessitates close attention to copyright, the total number of documents supplied in this way is relatively small compared with a library's total activity. Two studies provide some indication of the volume of photocopies supplied in the current paper-based system: Cornish (1990) estimated that ILL requests from outside institutions constituted, at most, only 3% of a library's total activity. In a separate study by Waldhart (1984), it was found that typically 60% of all ILL requests are delivered as photocopies (Waldhart, 1984).

Electronic libraries, however, have the potential to emerge as the principal source for information in the coming decades with electronic document delivery forming an essential component. At least for scholarly information, users may find themselves searching, requesting, and receiving documents electronically on a regular basis. In large, integrated information systems, literally millions of copies of a work may be accessed and copied by millions of users in this manner. The potential for multiple users to simultaneously access and make their own copies of documents will make the application of copyright law extremely difficult (Avram, 1989). A number of the most prominent issues regarding copyright and electronic document delivery are outlined below.

The concept of a copy One question that arises when considering the distribution of electronic works is what is to be considered copying, and when is it an infringement of copyright? The process of delivering a single document electronically can be argued to involve the making of a number of copies: one when the document is transmitted to a remote computer's memory, another when it is displayed on screen, another when it is saved to disc, and yet another when it is printed on paper (Oakley, 1989). At what point does such copying constitute an infringement of copyright? Oakley (1990) suggests that:

> when [a] work is distributed electronically, in whole or part, some of the copying that occurs may be problematic and some may not. One screen of data from a remote file need not be permanent, and in most cases would be insubstantial [and therefore fall under fair use]. But, if an entire work were copied from a remote datafile into the memory of a personal computer, a copyright owner might have a greater claim. He or she would be still more concerned if the work were saved to disk for later use or were printed out on paper (Oakley, 1990:15).

In short, viewing a single on-screen representation of a document may be justified as fair use (Oakley, 1989), but making an electronic or paper copy of the same document may be a violation of copyright (Oakley, 1990). Clearly, this is a problem for researchers who, quite naturally, may want to keep a copy of the document in their files, as they do presently with photocopies.

Fair use Some writers (e.g., Gilbert, 1990; Duggan, 1991), argue that the fair use principle must be extended to electronic information. This should be done in order to maintain the current role of the library "as distributor of information without charge to the public" (Duggan, 1991:20) and to maintain the free flow of information for scholarship, research, and education. In one sense, as Oakley (1989) points out, the ability to provide documents over a network may simply make the delivery of copies already allowed under fair use more efficient.

Yet, in another sense, it represents "a further step down the road of making copies available to readers without compensations to the author" and is a long way from the original notion of fair use (Oakley, 1989:34). One identifying characteristic of fair use is that coping must have a limited impact on the potential market for materials (Oakley, 1989). It may be argued that, in an electronic system that is a principal source of documents, the magnitude of copying may be such that it may seriously undermine the potential market for a particular document.

Library exemptions Another consideration is the effect electronic document delivery will have on the status of library exemptions. Recall that libraries may engage in copying provided it does not include multiple and systematic copying of materials to such an extent that it replaces the acquisition of the materials. As the number of documents available online increases, and distributed access to these documents from a variety of sources becomes transparent, multiple and systematic copying may become unavoidable. Such a system, in fact, would be designed specifically to seek out and retrieve documents from any source where they can be found without user intervention; multiple and systematic copying would be a matter of course.

Library exemptions, moreover, may not even be applicable in the case where users have the ability to interact directly with an information network—without intervention or mediation by the library (Oakley, 1989). It has been pointed out, in fact, that this particular section of (U.S.)

copyright law, if left unmodified, may "constrain the development of online networks" (Oakley, 1989:37).

Useright It has been argued that the notion of "copies" as the measure of a document's worth, and as a basis of compensation, is unworkable (OTA, 1986). In electronic document delivery, the whole process pivots on the making of copies: copies for storage, copies for transmission, and copies for display. In such a system, some other measure of worth will probably be required. As Oakley (1990) explains:

> ultimately, it may be that a new means of compensating authors will have to be developed. Many computer services now compensate copyright owners based on use. Some increase the level of compensation if a permanent copy is made, but compensation based on use rather than copies seems to be the norm in the electronic environment (p. 16).

Kost (1989) proposes the creation of a "useright" in the place of copyright in which useright holders would be compensated for the use rather than copies of their works. A fee for the use of materials is a concept already familiar to librarians in the form of the public lending rights that have been adopted by many countries (Cornish, 1990). Oakley (1990) asserts that the development of a useright would be "useful since it might permit the copying of the works, but necessitate compensation to the owner when the work was actually used by an individual" (p. 16).

Other areas of concern

Two other areas in which current copyright law may have a significant impact in the development of electronic document delivery systems are: 1) the effect of copyright upon the ability to create image databases; and 2) the notion of authorship. These areas of concern are outlined briefly below.

Imaging An issue related to electronic document delivery is the problem faced when making digitized copies of copyrighted material, such as journal articles and collections of photography and art. Essentially, if the print materials to be converted are copyrighted, then the act of making exact digital copies violates that copyright. Since one major source of documents for electronic document delivery will be digitized images, copyright issues will need to be considered at two stages: 1) during the creation of the initial images; and 2) during subsequent distribution of copies of the images through electronic document delivery.

The conversion of paper materials into digital form through scanning or other techniques does not currently fall within the provisions for photocopying set out in copyright law for libraries (Lyons, 1990). While scanning a copy for personal use may fall under the fair use doctrine, wholesale conversion, such as would be done when creating an image database, does not. The conversion process is considered to be a "distinct category of reproduction that would require a separate authorization from the relevant copyright source" (Lyons, 1990:9). In order to create image databases of traditional print materials, libraries will first have to determine the copyright status of the works in question, and then secure permission of the copyright holder before creating the database (Oakley, 1989). The process of obtaining permission, however, has been described as a "time consuming and expensive" process which may form "a barrier to a major conversion effort" (Oakley, 1989:28).

Once a database is created, making the images available in a network will raise the numerous questions about their distribution, as discussed above.

Authorship Electronic systems will change the manner in which authors go about their work and has the potential to dilute the concept of authorship and of individual property. For example, electronic information systems will allow the exchange of electronic documents among authors without ever requiring the document to become "tangible" in paper form, or for the authors of a particular document to know the existence of other contributors (Oakley, 1989). A document could theoretically be passed through a network repeatedly, with multiple authors contributing new ideas, or elaborating on existing ones, with no trace of who contributed what or how much. The holder of the copyright will be difficult to determine in such documents.

Electronic document delivery systems will also enable new forms of joint works to arise (Cartwright, *et al*, 1989). For example, ODA, a document model specifically designed to facilitate interchange and remote access to documents, allows the creation of electronic multimedia documents containing text and static images, and potentially moving images, voice, and sound. The problem that arises with such documents is that each separate element—audio, video, pictorial, and text—may have separate copyright restrictions that pertain specifically to the types of material represented. The composite documents, for example, may include literary, artistic, and musical materials which are treated as separate forms under copyright law.

A much more problematic case arises when these types of documents are combined with hypertext, embedding multimedia documents within multimedia documents. The result will be multi-layered, multimedia documents containing inextricable tangles of distinct copyright restrictions. It will be extremely difficult to apply current ideas of copyright to such unprecedented forms of documents.

6.1.3 Some proposed solutions to the copyright impasse

The forgoing discussion is by no means a full account of the above copyright issues, nor is it an exhaustive account all copyright issues that may impact upon future electronic libraries. While a complete resolution of these problems may be some distance away, a number of solutions have been proposed to deal with the inadequacy of copyright law in the current electronic environment, ranging from the complete overhaul of the copyright system to charging royalties for documents on a per use basis. Some of these solutions, derived from and found in greater detail in Oakley (1989), are outlined briefly below.

Amend current copyright laws

This view holds that the current property-oriented system of copyright should be retained and that most of the problems can be dealt with through a series of amendments that redefine concepts and make policy choices among various competing interests. Particularly problematic areas that require attention include:

- what materials are protectable and why
- whether the nature of information distribution has changed so fundamentally as to: 1) change what is permissible copying under fair use; or 2) create a need for expanded exemptions
- how intellectual property rights can be enforced in an era when so much information transfer takes place in private.

Overall revision of the copyright act

Another approach argues that the entire conceptual basis of copyright law is outdated and a complete revision, both conceptually and structurally, is required. Because the current body of copyright law was formed during the print era when the control of copies was straightforward, it is argued that it is completely inadequate to deal with the realities of the electronic and information age. Some anomalies that exist within the present electronic environment that are particularly problematic for copyright include:

- the fact that works needing protection may never exist in a fixed form, such as print or film, and may be distributed electronically without having to first become fixed
- the fact that works may be in a form that cannot be read directly by humans
- the dual nature of software that is both "writing" and therefore eligible for copyright, and also performs a function, making it a candidate for patent protection
- the ease and speed with which copies can be made makes "copying" something fundamentally different from the concept in pre-digital eras, making the control of copies inadequate as a basis for compensation

Design a *sui generis* copyright law

The *sui generis* approach is also based on the premise that certain types of intellectual property, such as software, cannot be appropriately protected by current copyright because they do not fit into its conceptual framework. Instead of attempting to bend existing law to cover each new form of intellectual property, however, the *sui generis* approach suggests that a new law be created to accommodate the particular characteristics of each new form. Such an approach has been used to protect computer chips, for example. In may be that the electronic delivery of documents is itself unique enough to warrant a separate law.

Increased reliance upon compulsory licences

Where the control over copies or use of a work is difficult, an alternative approach to copyright is to implement compulsory licenses. In compulsory licensing, "blanket permission" is granted to users of a particular work for a single fee paid to a central agency. Creators of works participating in the system are then paid royalties from the resulting pool of funds. This system was first created to compensate owners of copyrighted music such that subsequent recordings would yield a royalty.

The rates for the use of works are established in a variety of ways. They can be based on gross receipts (e.g., cable television), on the number of machine installations (e.g., music jukeboxes), for each individual work in a collection (e.g., tracks on an LP), and per performance (e.g., public broadcasting of a protected work). The organizations responsible for setting rates, collecting royalties, and distributing funds to copyright holders vary with the type of protected work. For example, in the U.S., the Copyright Royalty Tribunal sets rates and distributes royalties for cable television, record music, jukeboxes, and non-commercial broadcasting.

Recently, licensing schemes have been extended on a voluntary basis to the information industry. The Copyright Clearance Center, in the U.S., for example, is responsible for overseeing journal copying that exceeds the rates allowed by fair use and library exemptions. Royalties were initially collected on a per copy basis, but have recently changed to a single annual fee for major users, such as corporations. Difficulties in accurate projections of use is often cited as the reason to charge annual fees rather than per-use. The rates for annual fees are based on industry surveys and econometric modeling.

Compulsory license schemes may offer a solution to the problems of compensating authors for the use of their works in electronic document delivery systems. Mechanisms could be embedded with electronic document delivery systems to track the usage of a particular work (Oakley, 1989). In such a system, debits and credits could be applied to the accounts of information producers, distributors, and consumers automatically, based on the use of a particular piece of information (Kost in Avram, 1989). An integrated document delivery system, based on the standards and technologies discussed in this report, could be constructed to incorporate such mechanisms.

One negative impact of increased reliance upon licensing, however, is that the proliferation of this method threatens the supercedence of copyright law by contract law (Lynch, 1991a). The implications of this change are numerous. In the past, because only one body of copyright law applied to all cases, groups of individuals could assemble to assess and interpret a particular law and formulate guidelines for compliance, such as those developed for interlibrary loan (Lynch, 1991d). With site licences, however, there is no such uniformity; every negotiated contract between an information producer and consumer represents a *unique* agreement. If a library collects electronic information in various forms from a number of vendors, each form and each vendor may require a separate contract. When a user wishes to borrow the information, or use it in some unprecedented way, the absence of general guidelines requires that a legal opinion be sought to determine what can, or cannot, be done with the material. Further, if one institution wishes to form an alliance with another institution, then all of the separate agreements must be reexamined or re-negotiated to allow users from one institution to use the materials kept by another. Clearly, there is a danger in relying on contract law—and individually negotiated agreements—to deal with copyright problems (Lynch, 1991d).

6.1.4 International concerns

While domestic copyright laws governing electronic information may be inadequate, indeterminate, and confusing, the problem is even more extreme in an international context. This stems from the fact that it is difficult to synthesize different countries' copyright laws into a unified international standard (Miller and Blumenthal, 1986). Even though most countries have laws covering traditional forms of expression, they vary as to the protection they give new forms, such as electronic information. Furthermore, tension is growing between developed and developing countries in that the former wish to protect the information that is becoming an increasingly lucrative commodity, while the latter seeks greater access to the information to progress economically and socially.

6.2 Scholarly communication

Another area that will be affected as electronic documents are increasingly stored and delivered electronically is *scholarly communication*—the process by which intellectual and creative activity is transmitted from one scholar to another (Shaughnessy, 1989). The purpose of scholarly communication is manifold: to disseminate learned information, to establish the priority of scholars, and to act as the basis for tenure and academic promotion. Scholarly communication forms the larger framework of information production and dissemination of which electronic document delivery is a part.

Scholarly communication finds its genesis well over 23 centuries ago when ancient scholars began communicating their work to each other in writing (Osburn, 1989). Institutions, such as the Alexandrian Library, were formed to collect these writings and act as a nucleus of exchange. Scholarly communication was later advanced by the invention of the printing press in the fifteenth century that allowed a greater number of books to be printed, and thus a wider and more timely dissemination of information. Two centuries later, learned and scholarly societies formed to enhance communication and, in the end, developed the vehicle most central to scholarly communication: the scholarly journal. Journals established a formal arena for discourse, and allow the results of experimentation and study to reach a much broader readership.

6.2.1 Current methods and problems

At present, the scholarly communication system is a complex cycle involving researchers, scientists, publishers, and libraries, as well as a number of other constituents. In greatly simplified form, the cycle involves the following components (from Osburn, 1989; Rice, 1990; Shaughnessy, 1989):

- ***information producers***, the scholars, scientists, and researchers who, based on an existing body of literature, generate new knowledge through activities such as discovery, experimentation, interpretation, theory, accumulation of fact, and synthesis
- ***referees, scholarly societies, and publishers***, the editors and reviewers who effect the *peer review process*—determining the validity and relative significance of a particular contribution in a field by authorities in that field—and publish accepted works in paper-based journals and monographs producing a permanent and publicly available record
- ***indexing and abstracting services***, the companies that index and abstract the journal articles and create paper-based and electronic tools that aid in accessing the information
- ***libraries***, the organizations that identify, organize, store, and provide access to primary information, as well as to numerous finding tools
- ***information consumers***, the same scholars, scientists, and researchers who generated the knowledge in the first instance, who use it to generate new information, thus completing the cycle.

While this basic system has been very successful in making scientific information widely available for over three centuries, it is presently under severe strain. The explosion of the number of titles published and the "publish or perish" syndrome have glutted the system creating a number of problems (Shaughnessy, 1989). First, scholars often experience long delays from initial submission of manuscripts to final appearance in print journals because of the sheer volume of materials that must be reviewed and edited. This time-lag acts as an obstacle to effective scholarly communication as it slows the process of information dissemination. Such delays are most damaging when the information in question is time-sensitive.

A second problem is that, in some disciplines, the peer review process is short-circuited through the use of electronic mail and informal electronic "journals". Frustrated by the lengthy publication process, researchers resort to these methods to speed up information exchange (Shaughnessy, 1989). At a recent meeting of the Society of Scholarly Publishing, in fact, it was acknowledged that computer networks have become the dominate medium of communication among contemporary scholars in certain disciplines (Duggan, 1991). This circumvention of normal channels weakens the peer review process and has been called "the most critical factor in the breakdown of the scholarly communication system" (Shaughnessy, 1989:70). Furthermore, such informal communication is beyond the reach of libraries and eludes bibliographic control.

Yet another barrier to scholarly communication is the inability of libraries to purchase and maintain subscriptions to the burgeoning number of journal forms. Because libraries cannot collect all available titles, scholars either cannot get their hands on needed materials, or must wait days to weeks for documents to be delivered through interlibrary loan. Escalating prices for an increasing number of journals has, in fact, caused librarians to question a system wherein they are required to buy back the information that was created by their constituent population in the first place (Rice, 1990). Scholars who create the original information cede copyright to publishers, who then package it in journals and sell it back to libraries—at what have been criticized as exorbitant prices. Thus, as one writer states, "articles based on work created largely in universities and laboratories... ...become the property of organizations that own the rights, with the result that it is increasingly difficult for the public [i.e., libraries and scholars] to own and read publicly supported research" (Okerson, 1990:15).

It is important to point out that the various barriers to effective scholarly communication are not due to the philosophy or intent of the system itself, but to the mechanisms used in the organization, delivery, and control of the literature (Cohen, 1990). It is overworked and glutted, and new, more streamlined, automated methods are required to accelerate and more widely disseminate scholarly communication.

6.2.2 Electronic scholarly communication

As paper-based systems are replaced by electronic systems, alternatives to the present system of scholarly communication become possible. Many scholars already create manuscripts in electronic form on word processors. In an electronic scholarly communication system, these electronic manuscripts could undergo processes—online—similar to those of their paper-based counterparts. Specifically, these processes are blind reviewing, review by a panel of three scholars in the same field, and written comments to the author (Rogers and Hurt, 1990).

For example, a scholar could upload a manuscript created electronically onto a campus network where it could be indexed and made available to other scholars for comment. These scholars could electronically annotate the manuscript, providing "suggestions for reference to other literature, ideas for clarifying, arguments, rebuttals of arguments, notes of possible errors in data or interpretation" (Rogers and Hurt, 1990:5). Once the author responded to these comments, the final draft could then be submitted to selected expert reviewers for comment and adjudication, analogous to the current peer review system. Passing this, the work would then be formally incorporated into the literature with its permanent storage online. It would then become fully available for information retrieval, and linked to related research in the area (one way this could be done, for example, is through hypertext linkage of citations appearing in the body of the text). The creation and evaluation stages of the scholarly communication cycle thus would be automated in the same way that later stages, namely selecting, requesting, and receipt of documents online, can be automated through integrated document delivery systems.

Any number of local university-based online publishing systems could be created, and linked into an array through computer networks, to provide transparent access to all scholarly communication; each campus could serve and an "editorial node" that could be linked to other such nodes on other campuses (Yavarkovsky, 1990). Such an arrangement, of course, would require standards for creating, storing, and retrieving publications. Many promising candidates for these standards have been outlined in this study: standards for document representation (ODA, SGML, SPDL), standards for directories (X.500), as well as standards for distributed information retrieval (SR) and communications services (X.400 MHS).

An electronic scholarly communication system would have numerous advantages over the conventional system. An automated system would, for example (Yavarkovsky, 1990; Rogers and Hurt, 1990):

- provide a structure for the increasing informal online publication process taking place on the world's research networks
- provide a means to disseminate work not amenable to traditional paper-based media such as three-dimensional displays, graphic and pictoral material, and moving simulations
- provide a means to more widely disseminate research and cut across disciplinary boundaries
- save money spent on subscriptions, the housing of materials, and the processing of journals which can be invested in the electronic system

A number of obstacles, however, would have to be overcome in order for such a system to succeed (Lynch, 1990):

- authors may be deterred from embracing an electronic system because of the difficulty of preparing documents for submission in electronic form; new technologies, specialized software, and complex formats may have to be learned, as well as extra steps performed to created an electronic document
- electronic journals must be both widely known and widely accessible to fulfil the purpose of scholarly journals of providing recognition for authors and disseminating information. Not all disciplines, nor research institutions, possess the hardware base and level of connectivity to make such wide access possible. Furthermore, for disciplines that have a large international component, the disproportionate level of connectivity between countries may act as a deterrent to using fully electronic journals.
- electronic journals must be perceived to be as prestigious as paper journals, as well as a valid venue for publications in the race for tenure

- electronic articles must be as easy to read as paper journals, or easily convertible to paper form, for readers to accept them
- libraries must be convinced that electronic journals are worthy of collection. Acquisition, of course, may happen as a result of user demand, however, administrators may be reluctant because electronic journals may be perceived as "a more costly way of acquiring information currently purchased on paper, or a costly series of new journals to acquire along with the existing paper journals" (Lynch, 1990:24)
- libraries must develop and adapt to changes in operating procedures for electronic journal collection from claiming issues to whether the library stores a copy of the journal or simply acts as a gateway to it
- the collection of, or providing access to, electronic journals must be considered to be a valid factor in the ranking of major research collections in order for libraries to seriously consider dealing with them

6.2.3 The library/publisher relationship

An electronic scholarly communication system would profoundly affect the established patterns and institutions that currently control scholarly communication. While many questions need to be answered, a central question is whether scholarly publishers should retain the role of arbiter and publisher as they do in the present system, or whether this role would fall to some form of online university-based publishing network.

Some contend that universities themselves, in partnership with libraries, should assume the responsibility for publishing scholarly work instead of buying it back from third parties (Astle, 1989). Publishers, for their part, state that it would require much capital to cover startup costs, hire additional staff, and build market expertise. Yavarkovsky (1990) suggests that a likely alternative is a "symbiosis between university-based publishers and university libraries". He states that libraries will not become publishers, nor will publishers become libraries, but any particular library instead will be "a mix of library-loaded resources, purchased or licensed, and campus-based publisher-created resources produced online" (Yavarkovsky, 1990:17).

In the end, what may be of greatest importance is the alleviation of current strains on the scholarly communication system—burgeoning titles, slow publication process, and weakened peer review. Communication overload, Osburn suggests, "is a phenomenon as old as writing", and each time it has threatened, "means of gaining control over the communication flow were created" (1989:285). The development of an online scholarly communication system, as the development of the printing press and scholarly journal before it, may serve to assuage this most recent assault on the scholarly communication system.

6.3 Outlook for developing nations

Many developing nations have recognized the link between science, technology, and economic prosperity, and have embarked upon programs to organize domestic information systems that collect, process, and disseminate scientific and technological information (Gassol de Horowitz, 1988). These systems are considered to be necessary to improve the scientific and technological base of non-industrialized economies. Even where such systems have been created, however, they have had little impact upon the growth of science, technology, and social development due, in part, to the numerous constraints to the free flow of information (Dubey, 1986). Electronic document delivery, because it can provide remote access to primary documents, has the potential to deliver to developing nations the information resources that are considered essential to their economic and social development.

The publication systems of developing nations have been described as extremely poor with very low output. (Dubey, 1986). There is, therefore, a reliance on industrialized countries for primary sources of scientific and technological information. Because library budgets in these areas are often meager, however, they cannot acquire the materials for their collections, and must instead borrow heavily from libraries in other, primarily industrialized, countries (Mambomba, 1988). Unfortunately, document delivery systems that support such borrowing, and the flow of scholarly information in general, are hindered by many factors (Dubey, 1986; Mambomba, 1988):

- ***document delivery systems are encumbered by the distance between document suppliers and consumers***. This distance can often result in delays of four to six months for documents to arrive by surface mail. It also acts to increase the overall cost of the document, as well as the probability that it will be lost in transit

- ***problems of identification***. Access to bibliographic information for document selection is difficult to obtain. Access to online databases in developed nations is impeded by the lack of a telecommunications system, although the advent of CD-ROM has moderated this problem somewhat

- ***document supply systems are highly inefficient***. There are few book suppliers in developing countries who accommodate demands for foreign materials

- ***foreign exchange restrictions***. Foreign exchange restrictions limit the delivery of materials directly from producing countries

- ***the general increase in the costs of publications***. These increases are especially difficult for developing nations where poor economies are common

- ***increased costs as a result of photocopying***. The increasing use of photocopying and other electronic reproduction technologies in industrialized nations, and the concomitant decline in sales, have further increased the price of materials. This has additionally eroded the purchasing power of developing nations

- ***restrictive copyright laws***. The increasing use of photocopying and electronic reproduction technologies has caused copyright law to become more restrictive. Copyright restrictions tend to limit the flow of information outside its country of origin

- ***restrictions on transborder data flow***. The tendency of industrialized nations to restrict the transborder flow of information considered to be crucial to national security limits the information available to developing nations.

6.3.1 Electronic document delivery to developing countries

The use of electronic document delivery systems has the potential to overcome, or at least mitigate, some of the problems affecting the flow of information within developing countries. While it would be naive to think that all hindrances can be solved through the implementation of integrated electronic document delivery systems, a few examples of the problems that have the potential to be alleviated are:

- ***increased access to primary documents***. As electronic document delivery systems develop, the efficiency of overall document delivery should improve. This may provide the opportunity for developing countries to have direct access to documents in industrialized nations; problems of large distances, long delays, shipping costs, and losses of materials may, in this way, be eliminated

- ***improved publication systems*** It has been argued that one of the major impacts of the shift from paper-based information systems to integrated electronic document delivery systems, will be the acceleration of the scholarly communication cycle (Yavarkovsky, 1990); documents may be created, co-authored, edited, peer-reviewed, stored in final form, and accessed online. All scholars may have access to this system regardless of their physical location. This may provide new opportunities for scientists in developing nations to participate in scholarly communication

- ***mitigate problems due to copyright restrictions***. As discussed in a previous section, new copyright laws must be developed to accommodate the new electronic environment. Success in this area has the potential to redress the imbalance between information producers and consumers, caused by photocopying and other electronic reproduction technologies, and achieve fairer prices for materials. Electronic document delivery systems that have embedded charging mechanisms may ultimately reduce the cost of individual documents. This may potentially increase the purchasing power of developing nations.

6.3.2 Obstacles to electronic document delivery

Although electronic document delivery can be used to send materials to remote locations, one of the primary pre-conditions to its use is the existence of an adequate telecommunications infrastructure. Electronic mail, for example, is considered to be the network application that will play a large role in the delivery of electronic documents. One study that has examined the use of electronic mail in developing countries has identified a number of barriers to its implementation (Matta and Boutros, 1989). These barriers fall into four general categories: technological, economic, political, and sociocultural.

Technological barriers In general, the technological resources required to store and transmit data in less developed nations has been described as "inadequate", and the support mechanisms for its widespread use as "nonexistent" (Matta and Boutros, 1989:61,62). Specifically, technological barriers divide into three sub-categories:

- ***the lack of the necessary technology to receive, store and transmit data.*** This lack of necessary technology includes outdated computer hardware and software, limited use of microcomputers, few instances of LAN connectivity or connections between remote computer sites

- ***the lack of reliable land-based communication systems.*** The telephone system is the medium most frequently used for data transfer in developing nations, but in many places telephone systems are scant or non-existent. Furthermore, the transmission quality that they provide for audio and digital data in these countries is poor. (Packet radio, however, has the potential to provide connectivity solutions in developing nations where land-based communications are absent. Packet radio involves the transmission of data packets via radio rather than wires. For more information about packet radio, see Lynch and Brownrigg, 1987)

- ***the lack of sufficient technical support.*** This lack affects the maintenance and reliability of computer and telecommunications systems. There are shortages of systems analysts, programmers, and computer and communications technicians. Shortages of skilled labour also affect the reliability of the electrical power supply.

Economic barriers Severe economic conditions also restrict the development of computer related services. These conditions are manifested in a poorly trained labour force, illiteracy, high unemployment, lack of capital resources for investment, and crushing foreign debt. The purchase of the equipment necessary for computer/telecommunications capabilities is, therefore, beyond the reach of many less developed nations. Furthermore, the relative cost of manual methods is lower than investing in computer and telecommunications equipment.

Political barriers The political barriers to email, and other network services, stem from both internal and external nationalistic and protectionistic forces. For example, industrialized countries view information, as well as information technologies, as a valuable national resource;

the export of information and information technology are often restricted for both economic and national security reasons. The same is true of the importation of such materials; the governments of less developed nations frequently view Western technology as threats to national sovereignty (or at least to the sovereignty of those in power).

Sociocultural barriers Sociocultural barriers involve the problems of adapting foreign technologies to indigenous patterns. New technologies will have a profound impact on all levels of society. To use integrated document delivery systems effectively, individuals will have to overcome fear of computers, both because of the lack of computer literacy, as well as fear of displacement. While these factors do exist in industrialized societies, the fact that computer and telecommunications technologies have not been designed for the particular needs of developing countries may make the impact more severe.

The fact that a telecommunications infrastructure to support electronic document delivery must be created before the information necessary to economic prosperity can be made available, and that it will take economic prosperity to enable developing nations to afford a telecommunications infrastructure, is a vicious circle typical of many development issues. Nevertheless, the fact that electronic document delivery has the potential to provide access to the world's information resources, and the catalyst to change that this information can provide, will doubtless make the implementation of such systems in these nations an important issue in the future.

6.4 Other concerns

Several other issues that will arise as the management and delivery of electronic documents proliferates are worth noting. These issues involve document integrity, bibliographic control, and document archives.

Document integrity

In paper-based environments, the uniformity and consistency of publications is more or less taken for granted (Jeurgens and St. Clair, 1990); the content and layout of a particular paper document remains identical to all others in the same edition, whether the others are from different print runs, or are the output of a photocopy machine (with some allowances for changes in physical form). Such stability is due to the inherent qualities of paper and of reprographic technology, as well as to guaranties provided by the publisher that all instances of a particular document are identical (Eisenburg, 1989).

Electronic documents, on the other hand, are malleable to an almost infinite degree; they are not fixed in a permanent form, but can be edited, truncated, re-arranged, expanded, set in different fonts and layouts, and experience any other number of modifications. Through the intervention of the author, or worse, unauthorized persons, such documents could vary from instance to instance, making any particular "final form" an ephemeral entity. Even bit-mapped images and so-called non-processable formatted forms (such as in ODA), which appear at first glance to be fixed, may be ultimately modifiable. Products exist, for example, that can perform OCR on fax files. Guaranties provided by publishers would be useless in such circumstances.

Mechanisms will be needed, therefore, to stabilize electronic documents and prevent unauthorized modification. In addition, methods must be developed to keep track of changes in documents performed by authorized persons. Jeurgens and St. Clair (1990) suggest that the "audit trail" can be made explicit through the use of version numbers, similar to the scheme used presently with software: *1.0* to represent a first edition, *2.0* to represent a second edition, and *2.01*, *2.02*, and so on, to represent subsequent versions of editions. They also suggest adding *F* to the code, as in *2.02F*, to represent the final form. The issue that follows logically from this one, of course, is that of gaining bibliographic control of so many variations.

Bibliographic control

Bibliographic control of electronic documents will be much more difficult because of the malleability of this form of document. With paper-based documents, changes between successive versions of a single work are, for the most part, authorized, fixed, and recorded as separate editions. With electronic documents, by contrast, any number of authorized and unauthorized versions of a document may be created. Furthermore, these documents may exist in several forms, for example, as a scanned image, as OCR'ed text, or represented in ODA, SPDL, or SGML format. If these documents will be available within an electronic document delivery system, then some form of bibliographic control will have to be maintained. The nightmare scenario for librarians will be having to gain bibliographic control over documents for which there may be several versions, each in several formats.

Document archives

Electronic documents will need to be stored in perpetuity in the same way that paper documents are stored, even after they lose economic value. Currently, this is the role of large research libraries and legal deposit libraries. The same scheme of legal deposit must be extended to include electronic documents (Yavarkovsky, 1990). Additional concerns arise in the long term storage of electronic documents that do not arise with paper documents; that is, upward system compatibility must be ensured so that information in obsolete data formats continues to be available.

A related issue is the bankruptcy of electronic publishers; mechanisms must be established to ensure continued access to a publishing house's electronic "inventory" once the publisher has disappeared. For paper journals, continued access beyond the lifespan of a particular publisher is ensured by copies held in library collections. Ensuring continued access to electronic journals may be more problematic. For example, if a library only provides access to an electronic journal through a gateway, no other copies may exist other than what is located on the publisher's server (or in private collections). If the journal is discontinued, and the publisher's server shut down, general access to that material is lost. To ensure access to information in electronic journals in perpetuity, selected libraries will have to systematically store copies of electronic journals (Lynch, 1990).

7. CONCLUSION

Integrated electronic document delivery systems will form an essential part of the electronic libraries that may emerge as the principal source of information in the coming decades. These systems will increase the efficiency with which primary documents can be provided to end-users allowing them to select, request, and obtain documents directly from their local computers. Such systems will be necessary to correct the growing disparity between bibliographic access and document supply, and to increase access to an exponentially expanding body of information.

This study has attempted to provide examples of the manner in which various technologies—those for electronic document generation/conversion, storage, access, transmission, and production—can potentially be used to construct an integrated document delivery system. However, broad statements regarding the nature of future electronic libraries often obscure the complex and, at times, chaotic development of information technology. An integrated document delivery system will not appear rapidly in a revolutionary manner, but will most likely develop slowly "in an incremental fashion out of the existing library system" (Lynch, 1990:35).

The slow evolution of electronic libraries will stem from a variety of factors (Lynch, 1990):

- the need for an electronic corpus of literature to form the basis of an electronic library. This pertains to both the need for large-scale conversion of core works in the existing paper corpus, an expensive and time-comsuming process, and the need for wide-spread use of standard electronic document representations to create and maintain documents, particularly those for scholarly communication

- the need for the resolution of copyright questions such that electronic documents may be created and freely distributed throughout an electronic library in a manner that is equitable for both information producers and information consumers

- the need to develop mechanisms for bibliographic control of electronic materials to ensure access to a potentially very large and very dispersed body of materials

- the potential resistance to change of long-standing operational and administrative traditions within library and publishing organizations. The shift to electronic systems "will require basic changes in the way individuals and institutions think and do business" (Lynch, 1990:35).

- the necessity to create standards for linking abstracting and indexing record with primary material. A related problem is the need to first standardize abstracting and indexing records themselves as has been done for books through the MARC record

- the need to develop the infrastructure sufficient to support electronic document delivery. This means not only the development of high-capacity backbone networks, but the extension of such capacity all the way to the user's desktop. On the desktop, furthermore, there must be equipment suitable to support an EDD system, such as high resolution displays, large capacity storage options, and laser printers that provide the resolution and speed sufficient for EDD applications. While many computer-intensive disciplines such as engineering and the physical sciences may already have some of these high-end components, many other departments lag far behind.

Clearly, there is much groundwork to be done. Yet, it is only through the application of standards and technologies such as those discussed in this paper—and the concomitant solution of the many technical, social, political, and legal issues involved—that working electronic document delivery systems will appear. The present movement within the international academic community to create information networks offers the opportunity for such application: it can serve as a catalyst, and a focal point, for the integration of these technologies and the development of electronic document delivery systems.

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